SELECT LESSON PLANS AND ACTIVITIES FOR "GATEWAY TO GREENER PASTURES"

A PARTNERSHIP BETWEEN ANNEHURST ELEMENTARY, WESTERVILLE OHIO, AND METRO PARKS, COLUMBUS AND FRANKLIN COUNTY OHIO.

HONOR'S THESIS

By
Anna Isabel Patterson

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The Ohio State University
1998

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HONOR'S THESIS

Presented in Partial Fulfillment of the Requirement for the
Degree Bachelor of Science in the College of Food,
Agriculture, and Environmental Sciences of
The Ohio State University

By

Anna Isabel Patterson

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The Ohio State University
1998

Honor's Examination
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November 25, 1998

Dear Teachers and Administrators,

Students in the Honors Program in the College of Food, Agriculture, and Environmental Sciences at The Ohio State University are required to complete a project in their field of study. As a naturalist intern with Sharon Woods Metro Park and an Agriculture Education major, I developed my project in conjunction with the Metro Parks/Annehurst Elementary Partnership entitled "Gateway to Greener Pastures." The ultimate goal of this partnership is to increase Fourth Grade Ohio Science Proficiency test scores at Annehurst Elementary by three percentage points through exploration and investigation into science and natural resources at Sharon Woods Metro Park.

The following project consists of lesson plans and suggested activities to complement a visit to Sharon Woods Metro Park. The lesson plans are to provide teachers and leaders with a starting point from which to launch a natural resource curriculum that will actively involve students in science-based instruction at school and hands-on learning at Sharon Woods Metro Park. The plans aren't all-inclusive and leave plenty of room for activity additions and other lessons, which is their purpose. Hopefully the plans will introduce teachers to the topics, provide some background information, suggest related activities, and provide a sequence or order to follow in presenting the information. The objectives listed at the beginning of each section are based on a combination of the State of Ohio's Fourth Grade Proficiency Objectives and the objectives of the individual classes of Annehurst Elementary. A list of informative sources has been provided to supply you with additional information and activities.

I encourage each of you to take full advantage of this project and the partnership. Sharon Woods and the naturalist have a wealth of information to share with you and your students. Best of luck with proficiency tests and enjoy discovering what nature has to offer.

Sincerely,

Anna D. Patterson

Anna I. Patterson

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ACKNOWLEDGEMENTS

I would like to thank the following people for reviewing this project. Their ideas and suggestions were well received and greatly appreciated.

Dr. Beverly A. Good
Principal
Annehurst Elementary School

Mr. Gary Moore
Naturalist Coordinator
Columbus and Franklin County
Metropolitan Park District

Mrs. Susan L. Boggs
Interpretive Naturalist
Sharon Woods Metro Park

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INTRODUCTION

Sharon Woods Metro Park in Westerville, Ohio, is bordered on the south by I-270, the west by I-71, the north by Annehurst housing development and elementary school, and the east by Cleveland Avenue. I served as a naturalist intern at Sharon Woods from March 31, 1998 to December 9, 1998. During that time, Gary Moore, Naturalist Coordinator of the Metro Parks and Dr. Beverly Good, principal of Annehurst Elementary School, drew up a partnership entitled "Gateway to Greener Pastures". The rationale behind the partnership was the need for the Metro Parks to increase community awareness of available resources and the need for elementary students to actively investigate science to improve proficiency scores. Due to the proximity of Sharon Woods Metro Park to Annehurst Elementary School, a partnership between these two entities was only natural. Therefore, the goals of the partnership are 1) To raise the fourth grade Ohio Science Proficiency Test scores three percentage points; and, 2) To increase community awareness of Metro Parks' resources.

After the partnership was drawn up, the naturalist, Susan Boggs, and myself discussed the possibility of developing pre-information and post-activity packages to aid the teachers with the subject areas that would be addressed at the park. Most of the teachers have little experience with natural resources and have limited ideas as to where to start with instruction. Through my experiences with various school groups that came to the park for programs, I noticed that it was always beneficial to the students if they had been introduced to the topic of study at the school before they visited the park. This introduction to the topic of study created in the students a readiness to learn the topic. This pre-instruction is also beneficial to the naturalist because he or she can begin at a level of instruction that actually teaches the students. With the use of the pre-information and post-activity packages, the teachers will be able to introduce the students to basic concepts and ideas on specific topics before visiting the park to gain the hands-on experience in that area.

With the help of the naturalist, I matched the science course objectives at Annehurst Elementary and the fourth grade Ohio Science Proficiency Test objectives with current Metro Park programs. Many of the current Metro Parks programs address several science objectives relevant to the Science Proficiency Test and to the science curriculum at Annehurst Elementary. Therefore, the program topics chosen readily integrate into the science curriculum at Annehurst Elementary. These science objectives and current Metro Park programs are listed in the following pages.

After the programs and science objectives were matched, I worked closely with the naturalist and the third, fourth, and fifth grade teachers at Annehurst Elementary School to match the programs that would be offered to the different classes at the school. In order to match up the programs, we looked at the science objectives for each grade, the general themes that ran through each grade, and the level of difficulty of the concepts to be taught in each program area to decide which classes would focus on which programs. Some of the programs lend themselves best to certain objectives whereas others don't. Due to time constraints on the Sharon Woods naturalist, grades kindergarten through second will participate with school volunteers in the Wilder Elementary School's Woods Walker Program. Third, fourth, and fifth grade classes will attend natural science classes at the park throughout the year. Each teacher in those grades will receive pre-visit lesson plans and activities to prepare the students for the hands-on instruction at the park and post-visit activities to follow-up and reinforce the hands-on experience. In a cooperative decision made by the teachers, the naturalist, and myself, third grade classes will focus on Animal Adaptations and Herptiles, fourth grade classes on Habitat Exploration, Leaves and Trees, Pond Study, and Stream Study, and fifth grade classes on Forest Ecology and Deer of Sharon Woods. At this meeting we also set up the dates and times for the classes being held at Sharon Woods over the course of the upcoming year.

After working to match up the programs to the classes, I searched through references and guides to find information and activities related to each area and its focus. I developed lesson plans to introduce the activities and tried to place the activities and information in chronological order. The main purpose of the lesson plans and activities is to introduce the teachers to the subject areas, provide background information, and provide a sequential order to follow when presenting the information to the students. The lesson plans aren't all-inclusive and have been prepared so additional activities and plans can be added by the teachers. Hopefully the teachers will take advantage of the activities and classes at Sharon Woods to instill in students a desire to learn the natural sciences. With the students wanting to learn, hopefully their proficiency scores will increase. With students visiting the park, hopefully parents of the students and the greater community will become more aware of what the Metro Parks have to offer. My part in this task is to inform the teachers so they have a starting place from which to launch a natural resource curriculum with hands-on observation and instruction in both the classroom and at Sharon Woods Metro Park.

Gateway to Greener Pastures

A Partnership between Annehurst Elementary and Metro Parks

Introduction

Metro Parks compose a regional system of natural area parks. Its formal name is the Columbus and Franklin County Metropolitan Park District. It is a government agency created in 1945 (Ohio Revised Code, Chapter 1545). Since its formation, the Metro Parks have been dedicated to protecting nature and the environment by preserving natural areas. Metro Parks includes 10 parks and other land areas in Central Ohio. At this point in time, there is a need for Metro Parks to increase community involvement and to acquaint the public with the available resources. To meet this need, a link with Annehurst Elementary School is proposed. The partnership will serve as a prototype program and potential model for Metro Parks throughout Ohio.

Annehurst Elementary School is one of 14 elementary schools in the Westerville School District, Westerville, Ohio. The student population at Annehurst numbers 385 in kindergarten through grade five. There is a need to provide ongoing opportunities for the Annehurst students to actively investigate natural phenomena in the effort to improve student achievement in science. The Metro Parks' resources will set the stage for such investigation. The result of active science learning is improved student performance on standardized tests.

Rationale

Sharon Woods Metro Park, which is adjacent to Annehurst Elementary School, provides the setting for this partnership. As part of its strategic plan, Metro Parks is reaching out to the community and increasing awareness of Metro Parks' resources. Because of the programs that currently exist; the proximity between the Metro Parks offices, Sharon Woods Metro Park, and Annehurst School; and the willingness to explore partnership avenues, a prototype program is proposed.

The elementary school is a natural partner for this prototype. As Annehurst's students peer across the playground in to Sharon Woods, they can only imagine the intriguing phenomena that await exploration. The opportunity presented by a partnership between Annehurst Elementary School and Metro Parks has the potential to allow children to explore and investigate science phenomena. The proposed result of this opportunity is improved student achievement in science.

Goals

This partnership has two goals:

1. To raise the fourth grade Ohio Science Proficiency Test scores three percentage points and
2. To increase community awareness of Metro Parks' resources.

Objectives and Action Plans

Objective 1. Collaboratively match elementary science course of study objectives and fourth grade Ohio Proficiency Test science outcomes with Metro Parks programs.

Action Plan: Annehurst teachers and Metro Parks staff will meet to discuss the science curriculum and Metro Parks programming. Based upon this discussion, appropriate park resources will be identified and opportunities developed to help children achieve success on the fourth grade science proficiency test and competency based education tests.

Objective 2. Increase community awareness of Metro Parks' resources.

Action Plan: Metro Parks information will be included in Annehurst's monthly newsletters. For example, Metro Parks may provide articles and/or science related activities that students may do at school, home, or at a Metro Park. Programs of particular interest to families may be included.

Objective 3. Provide opportunities to increase knowledge of science and science process skills.

Action Plan: When space is available, Metro Parks will include one or two Annehurst teachers in its quarterly professional development for Metro Parks 'staff. As an added incentive to teachers, district inservice credit will be requested. Additional professional development activities that are related to natural history and environmental education will be explored.

Metro Parks will provide classroom visits up to a maximum of ½ day and 60 students per visit. During the visits, Metro Parks' naturalists will present information to students and teachers related to course of study concepts. Naturalists will model science process skills during presentations.

Metro Parks will assist Annehurst staff with the implementation of Wilder Elementary School's Woods Walker program. Implementation of Annehurst's Woods Walkers will provide the opportunity for teachers and students to understand environmental concepts.

Metro Parks' staff will model procedures for and involve Annehurst staff and students in seasonal stream monitoring. Data will be recorded and findings reported.

Led by the Annehurst staff, web pages will be collaboratively developed between Metro Parks staff, Annehurst staff, and Annehurst students. Pages will illustrate and explain partnership activities.

Objective 4. Metro Parks and Annehurst Elementary School will collaborate to secure a minimum of one corporate sponsorship to support partnership programs.

Action Plan: The Metro Parks naturalist, program coordinator, and Annehurst principal will seek corporate sponsorship for partnership programs.

<u>Notes</u>

Historically, transportation costs have kept students from visiting the Metro Parks. To overcome this obstacle, Metro Parks will alter the Sharon Woods policy which has provided only limited access through certain entrances. As part of the partnership, Sharon Woods staff will allow students to use the entrance that is adjacent to Annehurst Elementary School.

Metro Parks have a reference library and meeting room available at Spring Hollow. Although this facility will be out of service for about six months during its renovation, when completed resources at Spring Hollow will be available, as space and scheduling permit, for partnership-related activities, such as professional development. The non-circulating, reference library will allow Annehurst and Metro Parks staff to enhance their knowledge of natural history and environmental concepts.

Finally, as a neighbor and partner, Metro Parks and Annehurst will co-sponsor an annual community\Metro Parks event. Such an event may include providing a site for a parent night (i.e., an August welcome back to school or some type of kick--off for the new school year).

Evaluation of the Partnership

Success of the partnership will be evident from increased percentages on the fourth grade Ohio Science Proficiency Test and increased community awareness of Metro Parks' resources. Data to demonstrate the success of the partnership will be gathered relative to the four objectives. Data will be summarized and presented to Metro Parks' staff, and Annehurst teachers, and other interested parties.

Dissemination

The process by which the partnership develops as well as the goals, objectives, and evaluation summary will be provided to Ohio Metro Parks to illustrate a prototype partnership. The partnership will be nominated for the BEST awards to demonstrate the possibilities of such a partnership to a broad range of organizations. As stated, information relative to partnership activities will be available on web pages and in Annehurst newsletters.

FOURTH-GRADE PROFICIENCY TESTS
SCIENCE LEARNING OUTCOMES

1. Create and/or use categories to organize a set of objects, organisms, or phenomena.
2. Select instruments, make observations, and/or organize observations of an event, object, or organism.
3. Identify and/or compare the mass, dimensions, and volume of familiar objects in standard and/or nonstandard units.
4. Use a simple key to distinguish between objects.
5. Analyze a series of events and/or simple daily or seasonal cycles and predict the next likely occurrence in the sequence.
6. Evaluate a simple procedure to carry out an exploration.
7. Identify and/or discuss the selection of resources and tools used for exploring scientific phenomena.
8. Evaluate observations and measurements made by other persons.
9. Demonstrate an understanding of safe use of materials and/or devices in scientific activities.
10. Explain the operation of a simple mechanical device.
11. Identify characteristics of a simple physical change.
12. Explain and/or predict the motion of objects and/or describe the effects of some objects on other objects.
13. Make predictions about the weather from observed conditions and weather maps.
14. Identify and/or describe the relationship between human activity and the environment.
15. Identify evidence and show examples of changes in the earth's surface.
16. Demonstrate an understanding of the basic needs of living things.
17. Identify ways in which organisms react to changing environments
18. Distinguish between living and nonliving things and provide justification for these distinctions.
19. Analyze and/or evaluate various nutritional plans for humans.

Annehurst Elementary Third Grade Science Objectives

Program Objective I-A

Apply the processes of scientific investigation to explore phenomena .

Subject Objectives

1. Engage in a variety of scientific investigations. (S)

2. Use science process skills during scientific investigations. (S)

3. Describe observations accurately. Compare student's own data with data of peers, recognizing the limitations of human descriptions of phenomena. (S)

4. Use multiple sources, such as books, authorities, and observations, to investigate questions. (S)

5. Identify variables one at a time. (S)

6. Develop operational definitions. (S)

7. Interpret data. (S)

8. Formulate hypotheses. (S)

9. Observe events and discuss various influences affecting observations and interpretations. (S)

10. Explain and discuss various influences affecting observations and interpretations. (S)

11. Seek evidence to support ideas by asking "How does it work?", "How do we know?", and "Why?" (S)

Program Objective I-B

Integrate knowledge, skills, and themes that permeate the sciences and other disciplines.

Subject Objectives

1. Integrate and apply science knowledge and skills in all sciences and in other disciplines when appropriate. (S)

2. Describe phenomena by observed qualitative and quantitative attributes. (S)

3. Use mathematics and language arts as tools to build models and to express ideas. (S)

4. Construct physical models and dioramas to express ideas and conceptions of events and phenomena. (S)

5. Apply common arithmetic operations to whole number counts, measures of concrete objects, and observations to increase understanding and accuracy of descriptions and interpretations. (S)

6. Predict what is missing and what will come next in a sequence, then test their predictions. (S)

7. Use various modes of communication to express ideas effectively. (S)

Program Objective I-C

Use technology to collect, record, analyze, synthesize, evaluate, and to communicate data.

Subject Objectives

1. Use a variety of technologies including multimedia, weather instruments, thermometers, clocks, gauges, timers, and other measuring devices, to investigate science and to communicate findings. (L)

2. Record information in a variety of formats. (L)

3. Explore a variety of uses for technology. (L)

4. Use technology to expand the effectiveness of data collection, data organizaton, and data communication. (L)

5. Select and explore the use and accuracy of a variety of measuring devices. (L)

Program Objective I-D

Integrate science knowledge and processes into an authentic context such as problem solving and risk-benefit analysis.

Subject Objectives

1. Relate science knowledge and processes to meaningful experiences. (L)

2. Identify problems. (L)

3. Develop and carry out a problem solving strategy. (L)

4. Identify risks and benefits to a solution. (L)

5. Observe discrepant events and propose explanations for them. (L)

Annehurst Elementary Third Grade Science Objectives

Program Objective IV-A

Investigate the concept of evolution.

Subject Objectives

1. Identify, record, and develop theories for observed changes in the sky. (C)

2. Compare observed changes with descriptions in other resources and from other scientists. (C)

3. Describe and record characteristics of objects in the universe. (C)

4. Verbalize understanding of the natural world. (C)

5. Explore qualitative rates of change (e.g., faster, slower, bright, dim, loud, soft, cooler, warmer). (C)

6. Observe and record environmental patterns. (C)-

Program Objective IV-B

Explore, analyze, and synthesize the physical nature of science.

Subject Objectives

1. Systematically examine, record, and classify, in multiple ways, objects by physical properties and composition. (C)

2. Explore the relative contributions of each component in a system. (C)

3. Explore the properties of some objects and organisms (e.g., wind, magnets, static electricity, predators, pesticides, light, sound, soil, and water) to influence other objects and organisms. (C)

4. Explore the motion of objects and organisms. (C)

5. Investigate and evaluate types and interactions of matter, diversity, systems. (C)

Program Objective IV-C

Explore, analyze, and synthesize the nature of the universe and the earth.

Subject Objectives

1. Investigate properties of heat energy. (C)

2. Investigate and explore solid characteristics of earth. (C)

3. Observe and record earth's composition over time and describe the solid characteristics and patterns of the earth's surface. (C)

4. Explore various scales, such as time (clocks and calendars), distance (rulers and odometers) and tone (brightness and loudness). (C)

5. Explore estimations of observable time such as minutes, hours, days, and weeks. (C)

6. Systematically explore and investigate observed natural phenomena in indoor and outdoor settings over a variety of time spans. (C)

7. Obtain information from the environment. (C)

8. Explore unknowns in the natural world. (C)

Program Objective IV-D

Explore, analyze, and synthesize observations from the living environment.

Subject Objectives

1. Explore collections in various forms that represent the diversity of living and non-living things. (C)

2. Distinguish between attributes observed in living things and attributes suggested in literature. (C)

3. Describe similarities and differences between parents and their offspring. (C)

4. Explore qualitative and quantitative descriptions of objects and organisms. (C)

5. Explore and document needs, similarities, and differences of tiny creatures and large organisms. (C)

6. Investigate seed and pollen dispersion. (C)

7. Investigate crops in a variety of environments. (C)

8. Explore the diversity and interaction between living organisms and non-living objects. (C)

Annehurst Elementary Third Grade Science Objectives

Program Objective V-A

Explore historical scientific discoveries in the context of science and technology.

Subject Objectives

1. Relate an historical science contribution to its place in time and to the events of the period. (A)

2. Describe the relevance of an historical scientific contribution for current times. (A)

3. Dramatize milestones in the history of science. (A)

Program Objective V-B

Conduct student-based research to further their understanding.

Subject Objectives

1. Speculate on commonly held assumptions about events and phenomena in their world. (A)

2. Take things apart, and construct interpretations ofpurpose and functions of the parts things. (A)

3. Develop a strategy to conduct research. (A)

4. Evaluate decisions implemented during research. (A)

5. Reflect on and revise a research strategy as necessary. (A)

Annehurst Elementary Fifth Grade Science Objectives

Program Objective I-A

Apply the processes of scientific investigation to explore phenomena.

Subject Objectives

1. Engage in a variety of scientific investigations in sufficient depth to be confident of results. (S)

2. Use science process skills during scientific investigations. (S)

3. Describe observations accurately. Compare student's own data with data of peers, recognizing the insights and limitations of human descriptions of phenomena. (S)

4. Recognize that sometimes scientists have different explanations for the same observations. (S)

5. Use equipment and the human senses to collect information and to describe observations. Make accurate, honest, and reasonably appropriate scale readings. (S)

6. Ask "How do you know?" inquiries in appropriate situations by formulating and investigating reasonable "What might happen if...?" inquiries about everyday experiences. (S)

Program Objective I-B

Integrate knowledge, skills, and themes that permeate the sciences and other disciplines.

Subject Objectives

1. Integrate and apply science knowledge and skills in all sciences and in other disciplines when appropriate. (S)

2. Perceive and describe complex structures and events using appropriate concepts such as geometric configurations, duration, average rates of change, maximum and minimum, cause and effect, constancy, and change. (S)

3. Use reading, writing, and mathematics as tools for learning. (S)

4. Investigate living and non-living things holistically through models, simulations, multimedia, and technology. (S)

5. Maintain longitudinal journals of observations and inferences. (S)

6. Construct portfolios of products and self-evaluations of their own abilities, skills, and experiences. (S)

Program Objective I-C

Use technology to collect, record, analyze, synthesize, evaluate, and to communicate data.

Subject Objectives

1. Use multimedia to investigate phenomena and to communicate findings. (L)

2. Record information in a variety of formats. (L)

3. Explore a variety of uses for technology. (L)

4. Use technology to expand the effectiveness of data collection, data organization, and data communication. (L)

5. For a technical device, describe advantages and disadvantages to the user. (L)

6. Use optical technology to explore the effect of light on matter. (L)

Program Objective I-D

Integrate science knowledge and processes into an authentic context such as problem solving and risk-benefit analysis.

Subject Objectives

1. Relate science knowledge and processes to meaningful experiences. (L)

2. Identify problems related to science. (L)

3. Develop and carry out a problem solving strategy. (L)

4. Recognize that during a project, directions should be followed if they exist. Understand that if no directions exist or if unsatisfactory directions are given, the group or individual can often invent a way to complete the project. (L)

5. Gather and evaluate information from multiple sources which are related to science. (L)

6. Identify risks and benefits to a solution. Make and justify an informed decision. (L)

7. Consider risks and benefits before collecting, displaying, and maintaining

Annehurst Elementary Fifth Grade Science Objectives

I-A continued. . .

7 Accept and generalize results of investigations based on repeated observations and multiple sources. (S)

8. Determine the likelihood of event outcomes by identifying the causal factors, and speculate what additional factors may contribute to a more accurate prediction. (S)

9 Identify and control one variable. (S)

10. Develop operational definitions. (S)

11. Interpret data. (S)

12. Formulate hypotheses. (S)

13. Observe discrepant events and propose and test explanations the event. (S)

14. Critically analyze one's own data, and develop new research questions and a revised plan for data collection. (S)

I-B continued. . .

7. For an observed phenomenon, propose a variety of sources of information. (S)

8. Develop reasons, based on data recorded during an investigation, to use or avoid using consumer products. (S)

9. Identify factors that contribute to changes in a system and predict the next likely event for one or more components in the system. (S)

I-D continued. . .

organisms in the classroom. (L)

8. Choose and use appropriate tools to develop a model. (L)

Annehurst Elementary Fifth Grade Science Objectives

Program Objective IV-A

Investigate the concepts of evolution.

Subject Objectives

1. Identify, record, and develop theories for observed changes in the sky. (C)

2. Identify changes in the universe and relate them to changes on Earth. (C)

3. Compare changes observed outside the classroom with descriptions from a variety of resources and from other scientists. (C)

4. Develop models of structures and objects observed outside the classroom that are impossible to bring into the classroom. (C)

5. Investigate the regularity of motion found in the interactions in the solar system. (C)

6. Describe the implications for technology and natural systems suggested from investigations of easily measured distances and rates of change. (C)

Program Objective IV-B

Explore, analyze, and synthesize the physical nature of science.

Subject Objectives

1. Examine, record, and classify, in multiple ways, objects by physical properties and composition. (C)

2. Investigate relationships between models and scale. (C)

3. Distinguish between a system and a subsystem. (C)

4. Investigate and describe changes in motion. (C)

5. Investigate the impacts of various forms of mechanical and electromagnetic waves on various organisms and objects. (C)

6. Explore how light interacts with matter. (C)

7. Investigate the composition and levels of organization of objects and organisms (e.g., crystals, minerals, rocks, tissues, organs, organisms, etc.). (C)

8. Investigate various properties of

Program Objective IV-C

Explore, analyze, and synthesize the nature of the universe and the earth.

Subject Objectives

1. Investigate the technology used to explore the universe. (C)

2. Investigate the regularity of motion found in the interaction of the solar system (e.g., seasons, tides, planets, moons). (C)

Program Objective IV-D

Explore, analyze, and synthesize observations from the living environment.

Subject Objectives

1. Develop an organizational explanation of traits living things receive from parents. (C)

2. Observe diverse living cells, and investigate how they cooperate within an organism. (C)

3. Discuss and describe needs, similarities, and differences between tiny creatures and large organisms. (C)

4. Compare models of successful organisms in a variety of environments, and develop theories for their success. (C)

5. Investigate and describe symbiotic and/or interdependent systems. (C)

7. Investigate the diversity of methods by which living things meet their needs. (C)

8. Observe a living system and describe the effect on the system of changes to components. (C)

Annehurst Elementary Fifth Grade Science Objectives

IV-B continued. . .

groups of objects and organisms. (C)

9. Investigate the transmission and conservation of various forms of energy through biological and physical systems (e.g., electricity, weather, agriculture, etc.). (C)

10. Investigate conditions that affect the motions of objects and organisms. (C)

11. Observe a simple mechanical system and describe the effect of change on one component. (C)

12. Observe a physical change and develop and test a relevant "What if?" question. (C)

IV-D continued. . .

9. Trace the flow of energy in a living system. (C)

Annehurst Elementary Fifth Grade Science Objectives

Program Objective V-A

Explore historical scientific discoveries in the context of science and technology.

Subject Objectives

1. Relate a historical contribution to its place in time and to the events of the day. (A)

2. Describe the relevance of a historical science contribution to today's cultures. (A)

3. Explore the forms and functions of various historically significant technologies such as the bicycles, wheels, balls, scissors, and kites. (A)

4. Relate concept and technology of historical scientific significance to current use in a variety of cultures. (A)

5. Familiarize themselves with investigations performed by the global scientific community. (A)

6. Investigate the history and function of various techniques and technologies (e.g., sanitation, nutrition, hygiene, friction reduction, erosion control, crop rotation, agriculture). (A)

Program Objective V-B

Conduct student-based research to further their understanding.

Subject Objectives

1. Identify an area of interest to investigate further. (A)

2. Develop a strategy to conduct research. (A)

3. Execute a research strategy. (A)

4. Evaluate decisions implemented during research. (A)

5. Reflect on and revise a research strategy as necessary. (A)

Metro Parks

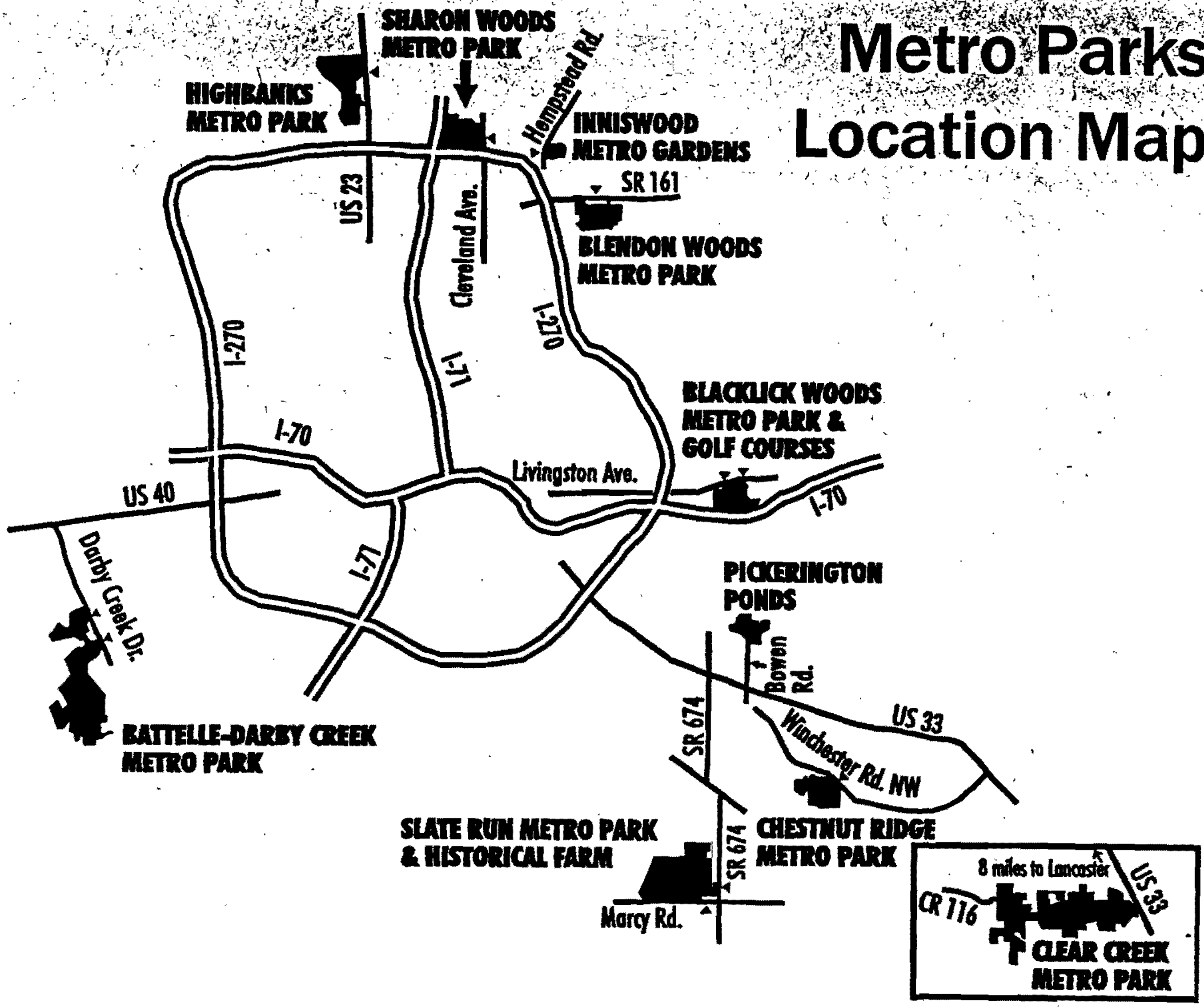
PROGRAMS

For Schools and Other Groups

You can schedule fun and educational natural and cultural history programs for your group.

See inside . . .

Metro Parks Location Map



METRO PARKS

PO Box 29169 • Columbus, Ohio 43229 • (614) 891-0700

Shipping Address: 1069 W. Main St.
Westerville, Ohio 43081
FAX: (614) 895-6208
TTY: (614) 895-6240

Dear Group Leader:

Thanks for planning a Metro Parks visit with your group. In addition to our regular park services, Metro Parks offers special group programs led by staff naturalists at no charge. These programs are structured to increase awareness and appreciation of natural and cultural history. We hope the enclosed materials and guidelines make your visit enjoyable and educational.

Planning Your Visit

- **Preparation.** Students will be more excited about learning if they review literature about Metro Parks, the park they will visit, and the topic selected prior to visiting. Please have younger students wear name tags.
- **Accessibility and disabilities.** Because most parks have trails that are steep in some areas, they may be difficult for younger children and those with disabilities. With sufficient notice, we can offer some programs in other areas. Please advise us of any special needs when scheduling, so our staff can provide information on services and facilities including accessible trails, signing interpreters, and assistive listening equipment.
- **Weather and cancellations.** All programs will be outdoors, rain or shine, so participants should dress for the weather. If a group is not coming for any reason, please call Metro Parks at 891-0700 (TTY 895-6240) to cancel as soon as possible. Programs will be cancelled in the event of severe or life-threatening weather (e.g., flood or tornado).
- **Alternative activities.** If more than one group is scheduled, plan alternative activities for the groups awaiting nature walks; don't assume that they can wait in the nature center. To receive a list of nature-related alternative activities, call Metro Parks.
- **Program topics.** The standard list of group program topics for each park details the season the program is offered, appropriate age levels, and the length of the presentation. Additional programs on a variety of natural history topics can be arranged with sufficient notice. Scout and other group leaders can request special topics that meet the requirements for naturalist, forester, and other nature-theme badges or awards. Topics and scheduling guidelines for all of the Metro Parks are enclosed.
- **Group size.** The minimum group size is 15; the maximum is 30. Group size minimums may be waived in consideration of individuals with disabilities.

When You Arrive

- **On site.** Our staff will meet your group at the prearranged location and time. (See enclosed map and permit.)
- **Punctuality.** Please arrive on time. Plan for early arrival if a restroom break will be needed. Groups arriving late will lose some or all of the time scheduled with the naturalist depending upon how late they arrive. Group walks normally last 45 to 90 minutes (depending on topic, age group, and park).
- **Supervision.** Conduct of the group is the leader's responsibility. Please accompany your class and maintain discipline on the trail. The ratio of adults to children should be one adult to every eight children for first graders or younger children and one adult to every ten children for second graders and older children.

Metropolitan Park District of Columbus and Franklin County: Battelle-Darby Creek, Blacklick Woods, Blendon Woods, Chestnut Ridge, Clear Creek, Highbanks, Inniswood Metro Gardens, Pickerington Ponds, Sharon Woods, and Slate Run

a system of regional natural-area parks

• **Regulations.** Metro Parks' rules are designed to protect visitors and natural resources. Groups should remain on trails, refrain from picking or collecting, and respect the peaceful nature of the trails. Complete regulations are available upon request. Contact Metro Parks at 891-0700 (TTY 895-6240) regarding requests to perform special studies (plot inventories, leaf collections, etc.)

After Your Visit

• **Discuss.** Students can benefit from a post-trip discussion of observations and discoveries. Topic activities can extend the learning experience back at school; ask a naturalist for other suggestions.
• **Write.** Letters from students and input from leaders help us determine what was learned and enjoyed on park visits, and are always welcome.
• **Evaluate.** As part of our continuing quest for excellence, we continue to monitor our services through participant evaluations. Please complete and return the enclosed evaluation form.

Community Outreach

In addition to conducting guided walks within parks, naturalists are available to give on-site natural history presentations for civic associations, clubs, and schools. School visits can be arranged for the months of November through March for a minimum of 60 students; a variety of natural history presentations are available. Presentations to civic associations and clubs are scheduled year-round for a minimum group size of 24.

Feel free to share this information with other teachers and leaders. We hope this information will help provide an enjoyable educational experience for your group. Please call if we can be of further service.

Sincerely,

Metro Parks Naturalist Staff

Sharon Woods

Metro Parks

School and Group Program Scheduling

Call 614/895-6246 (TTY 895-6240) for scheduling.

General Information

- Park address: 6911 Cleveland Avenue
- *If the group is not coming, a group leader should call Metro Parks at 891-0700 (TTY 895-6240) to cancel as soon as possible.*
- Unless previously arranged with the naturalist, all programs meet at the Schrock Lake west bulletin board.
- All programs are conducted outdoors; please have participants dress according to the weather.
- If more than one group is attending, please have an alternative activity planned for the group that is waiting.
- Please advise us of any special needs when scheduling so our staff can provide information on services and facilities, including accessible trails, signing interpreters, and assistive listening equipment.

Program Information

Season	Suggested Grades/Ages	Topic	Length
All year	Kindergarten-adult	Birds*	1 to 1¼ hours
April-October	Kindergarten-adult	Birds of Prey*	1 to 1¼ hours
All year	Kindergarten-adult	Deer of Sharon Woods	1 to 1¼ hours
April-September	1st grade-adult	Fishing*	1½ hours
April-October	Kindergarten-adult	Forest Ecology I	1 to 1¼ hours
April-October	4th grade-adult	Forest Ecology II*	1 to 1¼ hours
All year	Kindergarten-adult	General Nature Walk	1 to 1¼ hours
May-September	Kindergarten-adult	Insects	1 to 1¼ hours
All year	All ages	Mammals	1 to 1¼ hours
April-October	All ages	Pond Study*	1 to 1¼ hours
April-October	Kindergarten-adult	Reptiles and Amphibians	1 to 1¼ hours

Is your group studying a topic not offered above? With sufficient notice we can provide additional programs on a variety of natural history topics. Please ask and the naturalist will try to accommodate your needs.

*Special considerations; see * in program descriptions.

FORM #12:2/98

Program Descriptions

Birds: The program will feature adaptations, habitat needs, and a look at different groups of birds. During migration seasons (spring—March and April; fall—August and September) we will discuss and look for migratory birds. A 1-mile walk is included. *Binoculars are helpful but not essential.

Birds of Prey: This program helps children use their observation skills. We discuss Ohio birds of prey and their importance in our ecosystem with special emphasis on the adaptation of beaks, feet, and feathers. A short exploratory walk is included. *Binoculars are helpful but not essential.

Deer of Sharon Woods: This program offers information and a hands-on exhibition of items concerning the Metro Parks' deer dilemma. Participants will walk one mile.

Fishing: This basic introduction to fishing will include discussions of equipment, safety, and technique. *Participants 15 and under will have a brief chance to fish, weather permitting. A maximum of 15 people can be scheduled for this program. For youth groups, please have at least one adult for every five children.

Forest Ecology I: This is an introduction to the ecology of the wet woods at Sharon Woods. Children will explore the forest floor along the trail and discuss habitats, the process of succession, and decomposition on an exploratory walk.

Forest Ecology II: Older children will be given an opportunity to set study quadrants and learn how to evaluate the diversity of the forest floor. *Forest Ecology I is a prerequisite for this program. Wear bug repellent.

General Nature Walk: A 1-mile discovery walk will emphasize the importance of soil, air, water, and sunlight in our everyday lives. This program changes seasonally.

Insects: We will take a short walk to find and observe insects while discussing insects' adaptations, survival skills, and habitats.

Mammals: What makes mammals different from the other animals? How have they adapted to a constantly changing environment? We'll walk ½ to 1 mile.

Pond Study: This hands-on program deals with the importance of the food chain in an average body of fresh water. *Students should be prepared to get a little damp and dirty. The program is conducted from Schrock Lake fishing docks.

Reptiles and Amphibians: This program covers the life cycle of amphibians and reptiles as well as their survival needs. It includes a walk to explore the habitats of amphibians and reptiles.

Songbirds: A look at the migratory birds of central Ohio will feature adaptations of the birds' beaks and their habitat needs. A short exploratory walk is included. Binoculars are helpful but not needed.

Metro Parks

Your natural areas to learn and enjoy!

Metropolitan Park District of Columbus and Franklin County: Battelle-Darby Creek, Blacklick Woods, Blendon Woods, Chestnut Ridge, Clear Creek, Highbanks, Inniswood Metro Gardens, Pickerington Ponds, Sharon Woods, and Slate Run

a system of regional natural-area parks

Proficiency Test Objectives
(and how they relate to programs at Sharon Woods Metro Park)

The numbers listed here correspond with the numbered objectives of the Fourth Grade Proficiency Science Learning Objectives.

1. Organize a set of organisms or objects into groups according to shared characteristics.
    - habitat groupings
    - reptiles and amphibian classification
    - tree leaves

2. Read and interpret data and graphs. Take measurements and conduct counts then organize the data into tables and graphs.
    - conduct aquatic insect counts
    - chart the results of population counts
    - chart forest floor diversity within a plot
    - read growth and population charts of deer in Sharon Woods

3. Identify and compare measurements.
    - measure diameter and height of forest trees
    - rank the trees as to size (taking into account that some trees are wider while some trees are taller)
    - measure and compare aquatic organisms
    - measure an area in which to chart forest floor diversity

4. Use a simple scientific key to determine what an object is.
    - determine tree species
    - identify common wildflowers

5. Observe sequences and determine what the next likely outcome will be.
    - identify the steps to amphibian and reptile life cycles
    - describe the process of succession
    - determine which successional stage will come next
    - describe seasonal cycles in nature

7. Identify and describe the effects of human activity on the environment.
    - why has the deer population gotten out of control?
    - how is water quality affected by run-off?
    - what happens when water quality is poor?
    - what signs of human activity can you see having a negative impact on the park resources? Where is this human activity coming from?
    - how is the forest affected by humans?

9. Demonstrate an understanding of the basic needs of living things.
    - discuss animal needs for food, water, air, shelter, and companionship
    - identify the basic needs of plants and animals
    - describe the role habitats play in meeting the needs of animals and plants

14. Identify how plants and animals react to or have adapted to their changing environments.
    - discuss animal adaptations that have enabled them to survive
    - discuss plant adaptations to survival
    - identify those animals who have adapted to humans and our environment
    - discuss the seasonal changes of plants and animals

15. Distinguish between living and nonliving things.
    - identify those characteristics that make an object "living" (the ability to grow and change, the ability to react to its environment, the need for foods or energy, the process of taking in gases for respiration, the ability to reproduce, and being made up of cells)
    - discuss how some nonliving objects can sometimes exhibit living characteristics (such as a stream, stuffed wild animal, or fallen tree)

Programs Offered in Partnership with Annehurst Elementary

(Grades K-2 will participate with school volunteers in the Woods Walkers Program.)

Third Grade:

Animal Adaptations: This program will introduce students to the purpose of animal adaptations. Students will observe first-hand adaptations animals have that enable them to survive in their respective environments.

Focus: identify how animals have adapted to their environments

Herptiles: This program covers the life cycle of amphibians and reptiles as well as their survival needs. It includes a walk to explore the habitats of amphibians and reptiles.

Focus: organize organisms with shared characteristics - reptiles vs. amphibians
observe sequences - life cycle of amphibians
understand the basic needs of living things
identify how animals have adapted to their environments

Fourth Grade:

Habitat Exploration: This program will investigate several of the habitats at Sharon Woods including wet woods, fields, ponds, and successional areas. Students will learn to identify between living and nonliving things.

Focus: organize a set of objects with shared characteristics - habitats
observe sequences - succession
describe the effects of human activity on the environment
understand the basic needs of living things
distinguish between living and nonliving things

Leaves and Trees: This program is an introduction to the wet woods at Sharon Woods. We will discuss the importance of trees to people and wildlife. Tree identification and the use of a dichotomous key will be discussed.

Focus: organize a set of objects with shared characteristics - leaves
identify and compare measurements - trees
use a simple scientific key to determine what an object is
identify the effects of human activity on the environment
identify how plants have adapted to their changing environment
distinguish between living and nonliving things

Pond Study: This hands-on program deals with the importance of the food chain in an average body of fresh water. Water quality and pollution will be discussed.

Focus: take measurements and conduct counts, graph the information
identify and compare measurements
identify and describe the effects of human activity on the environment

Stream Studies: We will determine the biotic health of Spring Creek by seining and netting insect larvae, fish species, and other animals. The process of the water cycle will be discussed, along with water quality and pollution.

Focus: take measurements and conduct counts, graph the information
identify and compare measurements
identify and describe the effects of human activity on the environment
identify how plants and animals have adapted to their environment
distinguish between living and nonliving things

Fifth Grade:

Forest Ecology: This is an introduction to the ecology of the wet woods at Sharon Woods. Children will explore the forest floor along the trail and discuss habitats, the process of succession and decomposition, and will evaluate the diversity of the forest floor.

Focus: take measurements and conduct counts, graph the information
identify and compare measurements
use a simple scientific key to determine what an object is
observe sequences and determine the next outcome - succession
understand the basic needs of living things
identify how plants and animals react to their changing environment -
discuss the seasonal changes of plants and animals

Deer of Sharon Woods: This program offers information and a hands-on exhibition of items concerning the Metro Parks' deer dilemma. We will learn how the deer population got out of control and what can be done the slow their growth. We'll also discuss the biology of deer and how they fit into the food chain.

Focus: read and interpret data and graphs - deer populations
identify and describe the effects of human activity on the environment
understand the basic needs of living things
identify how animals have adapted to their changing environment

Animal Adaptations

Objectives:
- Explore and document the needs of various animals in certain habitats
- Engage in a variety of scientific investigations into animal adaptations to their environment
- Compare and contrast animal adaptations, focusing on birds and bats
- Discuss why adaptations are important to organisms

What to Teach	Teaching Suggestions
Introduce the concept of adaptations in animals.	- Set up a camouflage aquarium and question students as described in the activity "Surprise Aquarium".
Define adaptation in animals and discuss why animals adapt to their environments. adaptation – something animals have in order to survive in an environment	- Adaptations to an environment enable animals to survive by allowing them to blend into their surroundings. - Play the activity "The Thicket Game." This activity allows students to see how adaptations enable animals to blend in with their environments.
Question students.	- What are some other ways, besides camouflage, that animals use to adapt to their environments? - Answers: hibernation specialized parts changing color active at night et cetera
Discuss specific adaptations in birds that have better suited them to their specific environments.	- Birds have adapted to their environments in many ways, including beaks, feet, wings, eyesight, and coloration. - To better understand the adaptations in birds, see "A Necessary Skill" for background information.

What to Teach	Teaching Suggestions
Vision adaptation in birds and other organisms.	- Activity "Seeing is Believing or The Eyes Have It!" - Discuss with students vision adaptations in animals. See Bird Vision Q: Why would a predatory animal (such as a wolf or hawk) need to see long distances? Q: Rabbits and chickens have eyes located at the sides of their faces. Why would they need to see around them? - Activity "Wolves and Rabbits" discusses the differences in vision between rabbit eyes and wolf eyes.
Beak adaptations to enable birds to gather different foods.	- Activity "Fill the Bill"
Feet adaptations of birds that allow them to adapt to their habitats.	- Activity "Feet are Neat"
Bat adaptations. How have bat wings adapted to flight?	- Background information "Bat Information" and Flight Facts" - Bats are mammals, they have approximately the same skeletal structure we have (especially the comparison between bat wings and human hands). Bats have adapted their "hand" bones to become a wing. How do hands and their wings compare? - Activity "Inside a Bat"
Bats and sound	- Background information "Echolocation" - Bats have adapted to use sound, instead of sight, to locate prey at night. They do this though echolocation. - Bats have extremely sensitive ears, many are larger than normal, that allow them to hear better. - Activity "Sensational Ears"

What to Teach	Teaching Suggestions
Visit to Sharon Woods Metro Park	**- The naturalist will discuss and show examples of adaptations in wings, feathers, eyes, and feet, compare bird and bats wings, and discuss echolocation.**
Review and compare bird and bat wings.	- Review adaptations in bird and bat wings. - Compare and contrast bird and bat wings through the activity "Wings 'N' Things"
Tie together adaptations in birds.	- Students will design a bird adapted to its habitat. - Follow the guidelines in the activity "Adaptation Artistry."

SURPRISE TERRARIUM

Objectives

Students will be able to: 1) identify camouflage as an example of adaptation in an animal; and 2) describe the importance of adaptation to animals.

Method

Students observe a live animal using camouflage techniques.

Background

NOTE: See "Thicket Game" and "Seeing is Believing."

One of the most important ways that living things survive is by their ability to adapt—to climate, soils, water, vegetation, other life forms, and other ecological factors.

Animals that use camouflage techniques can be particularly interesting and visually compelling to young students as a means of illustrating the concept of adaptation.

The major purpose of this activity is for students to recognize that animals adapt to survive.

Materials

terrarium with vegetation, and one animal suited to the kind of habitat components represented in the terrarium (the animal should be one that uses camouflage as a form of adaptation to survive; e.g., leaf hopper, tree frog, tree lizard, walking stick, grasshopper, earthworm); photos of animals using camouflage or magazines the students can use to find photos

NOTE: See the National Science Teachers Association's "Code of Practice on Animals in Schools" in the Appendices for suggestions concerning proper housing and care for animals in the classroom.

Procedure

1. Make a "surprise terrarium" for your students, and bring it to class. The terrarium should contain an animal that is hard for the students to see at first, because the animal uses camouflage as an adaptation technique.
2. Encourage the students to observe the terrarium, wondering if an animal might live there. Ask them to describe what they see.
3. Ask the students to think of animals that blend with their environments. Talk about their ideas. Show photos, or bring in magazines and ask the students to look for pictures of animals that look so much like where they live they are hard to see. Are the animals camouflaged? Camouflage is one way animals adapt in order to survive.
4. If they haven't found the animal who is living in their terrarium, encourage them to look very closely until they do.
5. Ask the students to summarize some of the things they have learned about "adaptation" and its importance to animals.
6. Optional: If the camouflaged animal was brought into the classroom from the wild, the students may participate in the process of returning the animal to its natural home. This is a good time to talk about human responsibilities for proper care of animals used for instructional purposes, as well as a potential way to see the animal camouflaged in its natural setting.

Evaluation

Name two animals that use camouflage, and talk about how camouflage is important to these animals.

Age: Grades K-3 (and older)
Subjects: Science, Language Arts
Skill: application, discussion, generalization, observation
Duration: 20—30 minutes
Group Size: any
Setting: indoors
Conceptual Framework Reference: III.D., III.D.1., III.D.2.
Key Vocabulary: adaptation, camouflage

THE THICKET GAME

Objectives
Students will be able to: 1) define adaptation in animals; and 2) generalize that all animals make some adaptations in order to survive.

Method
Students become "predator" and "prey" in a version of "hide and seek."

Background
Animals are adapted to their environment in order to survive. Animals may be adapted to changes in their habitats. For example, snowshoe rabbits have a white winter coat to blend with a snowy environment and a tan summer coat to blend with summer ground and vegetation colors. Chameleons change color to blend with their surroundings. The walking-stick insect can look like a twig or stick. Fawns have spotted hair that resembles dappled light on the forest floor.

The major purpose of this activity is for students to understand the importance of adaptation to animals.

NOTE: See "Seeing is Believing" and "Surprise Terrarium" for other elementary-age adaptation activities.

Materials
blindfolds; outdoor area like a thicket or other vegetated area where students can safely hide

Procedure
1. Take the class to a "thicket."
2. Blindfold one student who will be the "predator." The predator counts to 15 slowly while the others hide. The students hiding must be able to see the predator all the time.
3. After counting, the predator removes the blindfold and looks for "prey." The predator can turn around, squat, and stand on tip-toes—but not walk or change location. The predator should see how many students he or she can find, identify them out loud and describe where they are. When identified, they come to the predator because they have been "eaten." These prey now become predators.
4. When the original predator cannot see any more students, all the predators now put on blindfolds. The original predator counts aloud to ten. All the remaining prey are to move in closer, but still try to be "safe" and hidden. All the predators remove their blindfolds and take turns naming students they can see.
5. Repeat the process if several students are still hidden. When only one or two are left hidden,

Age: Grades K-6
Subjects: Science, Physical Education, Language Arts
Skills: analysis, application, description, discussion, generalization, kinesthetic concept development, observation, psychomotor development
Duration: 30 minutes
Group Size: minimum of five students
Setting: outdoors
Conceptual Framework Reference: III.D., III.D.1., III.D.2.
Key Vocabulary: adaptation, predator, prey

have them stand up and identify themselves; it may be surprising how close these prey were to the predators—an example of successful adaptation because of how well they blend with their environment in order to survive. Introduce the term "adaptation."

6. Play the game again one or two times.

7. Discuss what would have made it easier to be the last one or get very close to the predators. Some ideas that may come out are: changing color (clothes); wearing clothing that doesn't stick to plants; being of smaller size; climbing a tree.

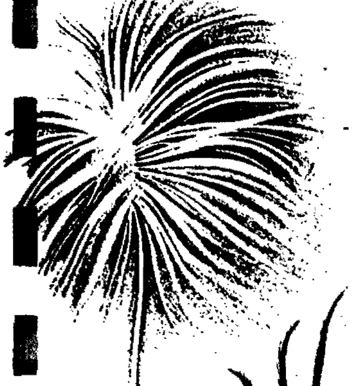
8. Ask the students to summarize what they have learned. See if the students can think of other examples of adaptation in animals. Generalize that all animals are adapted to survive.

Evaluation

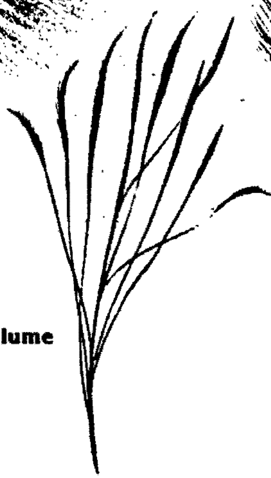
Describe the importance of adaptation to animals. Give at least two examples of animal adaptation.

A Necessary Skill

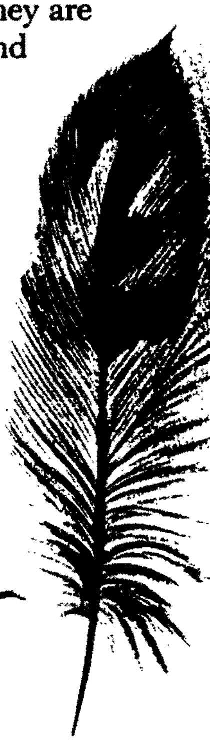
In nature, predators are needed. They eliminate insects and vermin as well as animals that are not fit to survive. Birds of prey do their job without cruelty. They are equipped to be efficient and quick. In most cases, the prey does not suffer.



Down feather



Filoplume



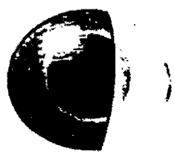
Contour feather

Flight feather

Birds of prey usually have large and bright eyes. They have three eyelids to protect their eyes . . .

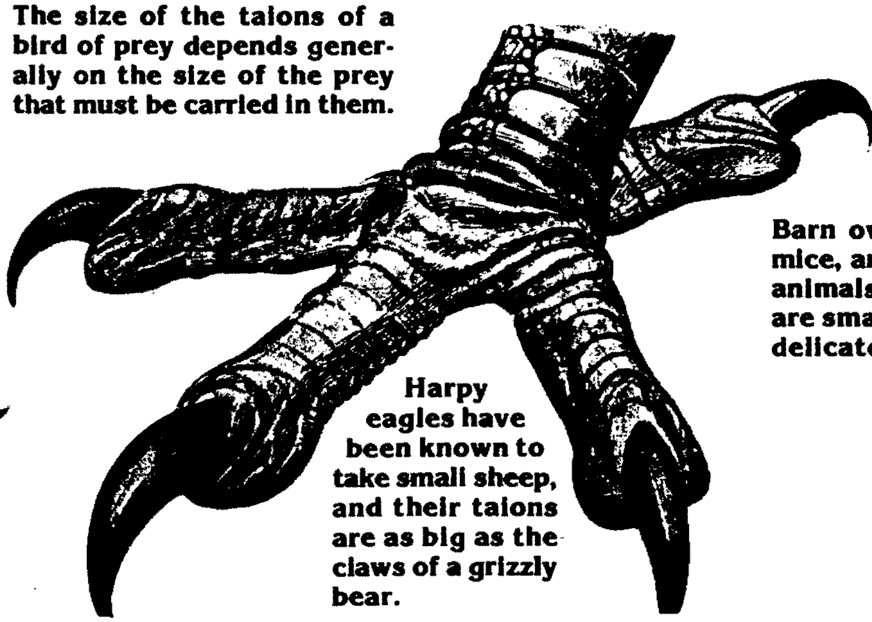
Hawks close their eyes most of the time by moving their lower lids up.

Owls move their upper eyelids down—adding to the human appearance of their faces.



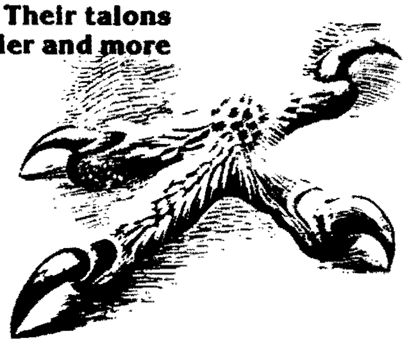
The third eyelid, called the nictitating (*NICK-tit-ate-ing*) membrane, closes from side to side. It moistens and cleans the eye.

The size of the talons of a bird of prey depends generally on the size of the prey that must be carried in them.



Harpy eagles have been known to take small sheep, and their talons are as big as the claws of a grizzly bear.

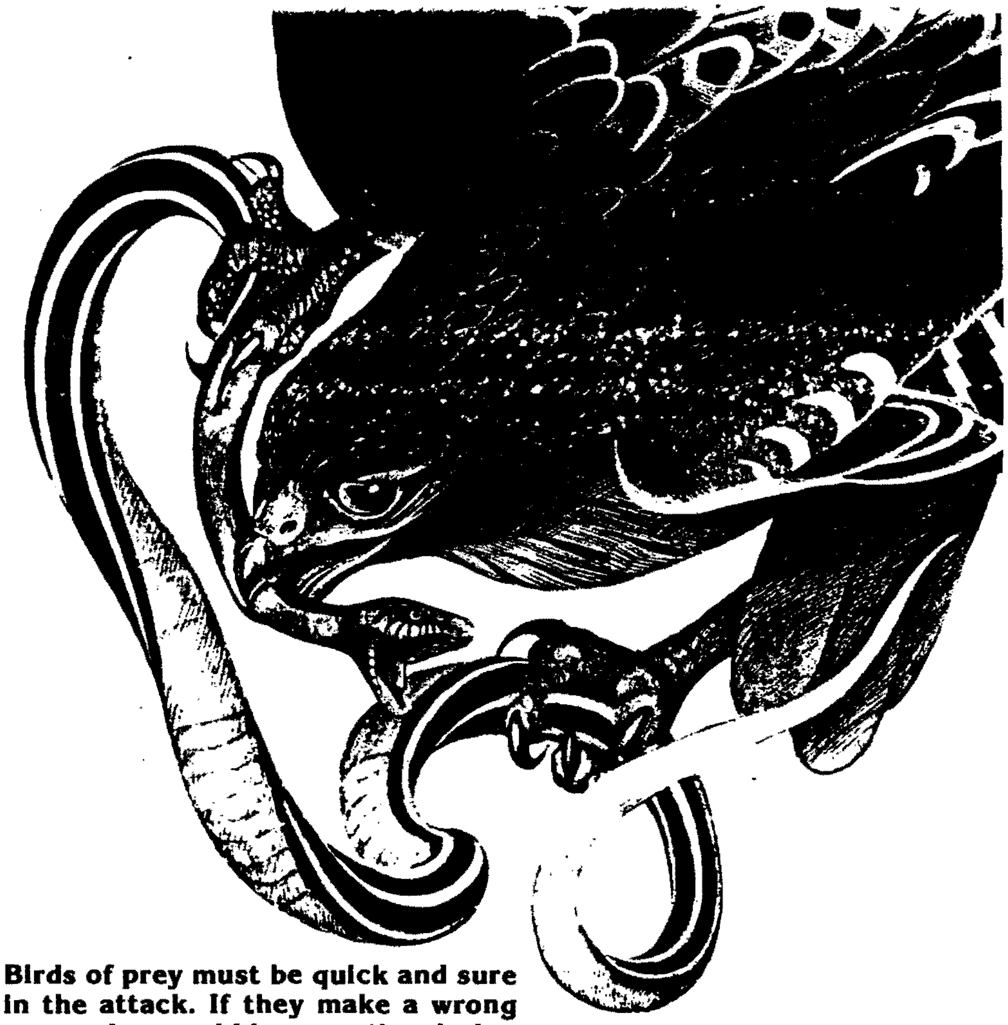
Barn owls take rats, mice, and other small animals. Their talons are smaller and more delicate.



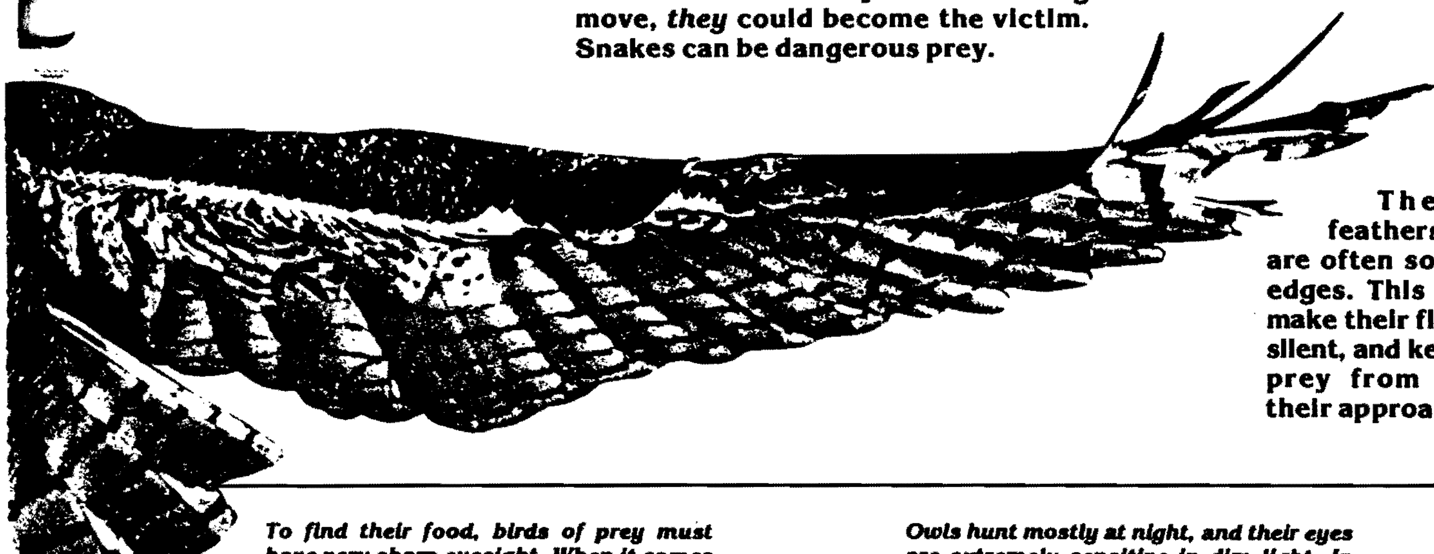
The size and shape of the beak depends on the kind of prey. Small birds like the American kestrel have short beaks for eating insects and other small animals.

The Everglades kite has a long and curved beak for probing inside the shells of snails.

The bald eagle has a heavy and powerful beak for taking apart large pieces of meat.

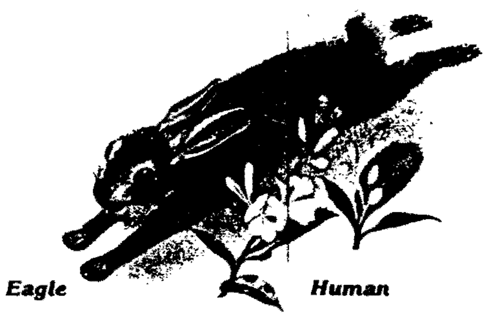


Birds of prey must be quick and sure in the attack. If they make a wrong move, *they* could become the victim. Snakes can be dangerous prey.

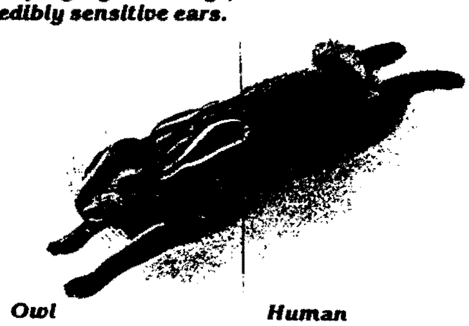


The flight feathers of owls are often soft at the edges. This helps to make their flight very silent, and keeps their prey from hearing their approach.

To find their food, birds of prey must have very sharp eyesight. When it comes to seeing objects at a distance, their eyes can be 8 to 10 times better than human eyes. A Golden Eagle can see an 18-inch-long rabbit at a distance of up to 2 miles.

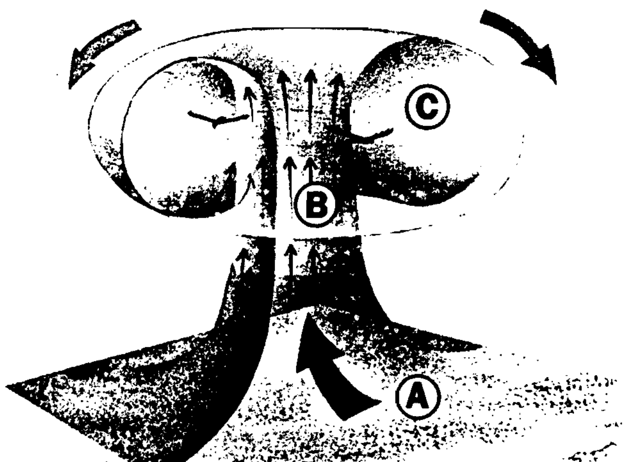


Owls hunt mostly at night, and their eyes are extremely sensitive in dim light. In the dark, they are able to see from 10 to 100 times better than we can. When it is too dark for even an owl to see, they can still locate prey by listening for it with their incredibly sensitive ears.



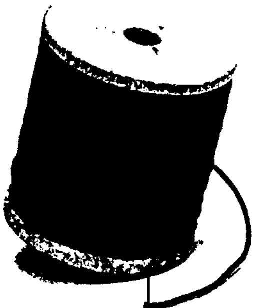
Soaring high above the earth on motionless wings, an eagle is in the perfect place to see prey below on the ground. All eagles have wonderful eyes that can focus on small objects at long distances. An eagle can probably see a rabbit two miles away.

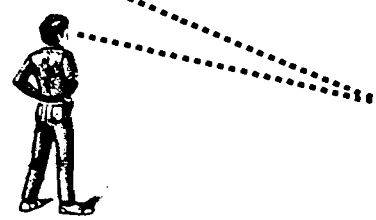
To rise really high into the air, eagles often hitch a ride on rising bubbles of hot air called "thermals." Once an eagle gets into a thermal, it can just spread its wings and float upward with very little effort, as explained below:



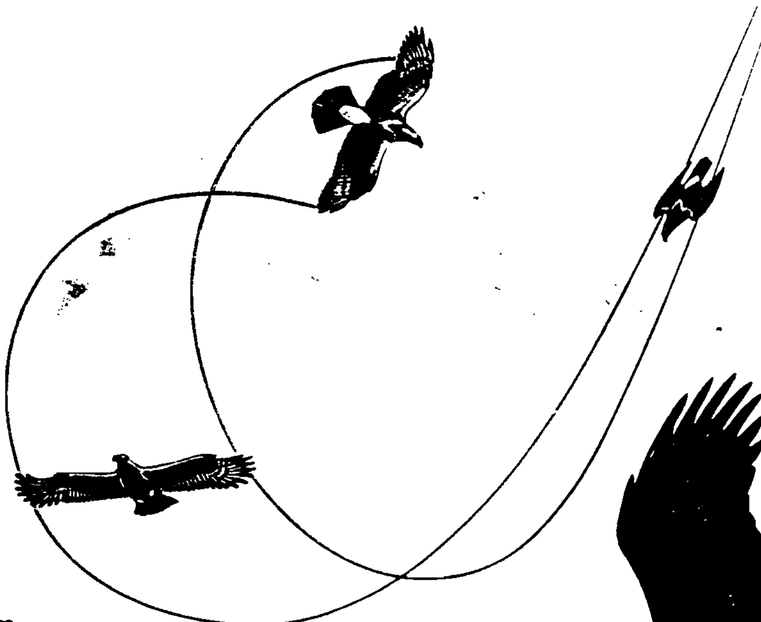
Thermals are formed when the sun warms the air near the ground Ⓐ. Hot air is lighter than cold air, as you know from watching steam rise out of a tea kettle. So the heated air rises Ⓑ. Eagles place themselves in the middle of the rising air and float upward with it Ⓒ. When a thermal is big, the eagles may climb to 3 miles above the earth (5 kilometers).

The ability of eyes to focus on objects at a distance is called "resolving power." Eagle eyes have resolving power that can be *8 times better* than the resolving power of human eyes.





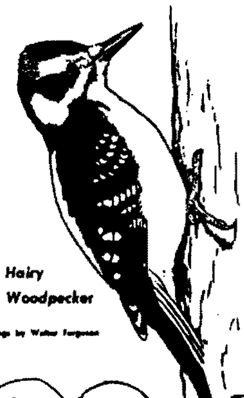
SEE FOR YOURSELF how good an eagle's eyes can be. Get a spool, or something else that is about one inch long (3 centimeters). Put the spool down on the ground and start backing away from it. When you can't see the spool anymore, you have reached the limits of your eyes' resolving power. Measure the distance and multiply by 8—and you will know how far away an eagle could be and still see the spool.



SEE FOR YOURSELF how the wide wings of many eagles make it easier for them to stay up in the air. Get two pieces of paper the same size. Fold one as shown below. Drop both pieces at the same time from the same height. See w the narrow paper drops faster than wide paper, even though they both gh the same.

Eagles are wonderful flyers, and they often seem to do their most spectacular tricks just for the fun of it. Some eagles can swoop through the air at incredible speeds, as shown above. As they dive, they may go as fast as 200 miles per hour (325 kilometers). Other eagles turn over and over and over, as shown at left. And sometimes, pairs of eagles may lock their claws together (as shown at right), and spiral down for thousands of feet.

adapt 10



Hairy Woodpecker

Drawings by Walter Ferguson

BIRD STUDY *Bills, Feet, Tails* and *Wings* reveal many bird habits —

they are wonderful examples of nature's amazing ingenuity in solving the problems of survival.

FOR EXAMPLE:

the WOODPECKER'S strong, chisel-shaped *bill* is adapted for chipping wood as a means of boring into trees in search of grubs. Its *feet* have two sharp toes directed forward and two backward which clamp the bird securely to the tree trunk in an erect position. Sharp-pointed *tail* feathers act as props to steady the woodpecker while it uses its bill as a hammer.

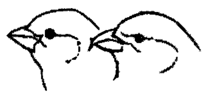
***BILLS* of birds are variously adapted for procuring different foods and serve also for nest building, preening feathers and for protection.**

***FEET* are built for perching, scratching, walking, swimming, for seizing prey.**

***WING* size and shape vary greatly. Some wings are designed for soaring, for sudden turns and rapid flight, for easy long distance travel.**

***TAILS* provide balance when perching and flying; are rudders during flight.**

Adaptations of BILLS



SEED-EATING—(a) short, thick bill for crushing seeds. *Examples:* Sparrow, Grosbeak, Bunting,—Finch *(shown)*

(b) upper and lower mandibles crossed to enable bird to extract seeds from cones of evergreen trees. *Example:* Crossbill *(shown)*

INSECT-EATING — (a) slender, pointed beak for picking up insects. *Examples:* Warbler,—Vireo *(shown)*

(b) very wide mouth for catching insects on the wing. *Examples:* Swallow, Nighthawk, Swift

PROBING—(a) long, slender bill for probing in mud in search of food. *Examples:* Snipe *(shown)*, Woodcock, other Sandpipers

(b) long, slender bill for probing the necks of flowers to feed on nectar. *Example:* Hummingbird

PREYING—strong, sharp, hooked bill for tearing flesh of prey. *Examples:* Owl, Hawk, — Falcon *(shown)*

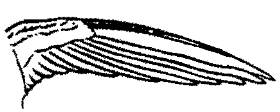
STRAINING—broad, flattened bill for straining food from mud. *Examples:* Flamingo, Duck,—Goose *(shown)*

GROUND-FEEDING — short, stout bill for feeding on the ground, as a hen. *Example:* Bob-White *(shown)*

FISH-EATING—(a) long and sharp for spearing fish. *Example:* Heron *(shown)*

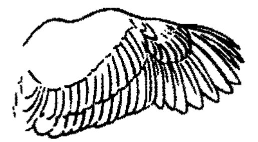
(b) with a flexible pouch underneath bill for holding captured fish. *Example:* Pelican *(shown)*

Adaptations of WINGS



Long, pointed wings for fast, easy flight in the pursuit of flying insects. *Examples:* Swallow,—Swift *(shown)*

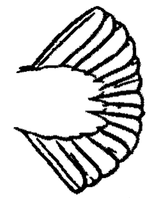
Long, broad wings for strong, soaring, effortless flight. *Examples:* Hawk *(shown)*, Eagle



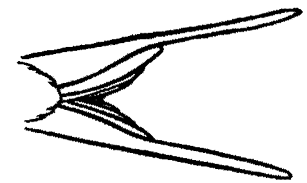
Short, rounded wings for speedy take-off and fast flight over comparatively short distances. *Examples:* Sparrow, Quail,—Pheasant *(shown)*, Woodcock, Grouse

Adaptations of TAILS

Tail feathers with strong, spine-like tips for use as a prop or support when clinging to vertical surfaces. *Examples:* Woodpecker, Swift,—Brown Creeper *(shown)*



Broad, fanned tail for soaring. *Example:* Buteo-type Hawk *(shown)*

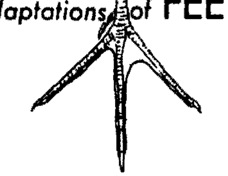


Long, forked tail for graceful, skimming flight and extreme maneuverability. *Examples:* Tern, —Barn Swallow *(shown)*, Frigate Bird, Swallow-Tailed Kite

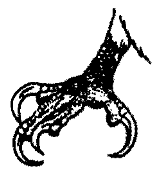
Adaptations of FEET

PERCHING—three toes in front, one toe behind. Most familiar birds are of this type. The foot automatically clasps the perch when the leg is relaxed. *Examples:* Sparrow, Chickadee,—Robin *(shown)*

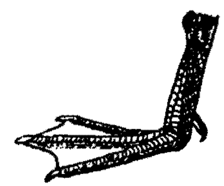
WADING—long legs, long, slender toes. The three long toes keep bird from sinking into the mud. *Examples:* Gallinule, Heron,—Sandpiper *(shown)*



PREYING—powerful feet and legs with strong, curved, sharp talons for grasping prey. *Examples:* Hawk, Owl,—Eagle *(shown)*



SWIMMING—three front toes fully webbed. *Examples:* Goose, Gull,—Duck *(shown)*



CLIMBING—two toes in front, two toes in back; sharp claws for clinging to an upright surface with ease. *Example:* Woodpecker *(shown)*

SCRATCHING — claws strong and blunt for raking or scratching the ground for food, as a hen. *Examples:* Pheasant, Quail,—Grouse *(shown)*

Educational Services
NATIONAL AUDUBON SOCIETY
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SEEING IS BELIEVING or THE EYES HAVE IT!

Objective

Students will be able to identify different kinds of vision as an example of adaptation in animals.

Method

Students use kaleidoscopes, binoculars or telescopes, and fish-eye mirrors; imagine what animals might have such vision; and make posters showing animals that do have such vision.

Background

NOTE: See "Thicket Game" for information about animal adaptation. Also "Surprise Terrarium."

Vision is one example of animal adaptation—with different kinds of vision well-suited to the needs of different kinds of animals.

The major purpose of this activity is for students to recognize different kinds of vision as examples of adaptation in animals.

Materials

set up three learning stations: one with a kaleidoscope, one with binoculars or telescope, and one with a fish-eye mirror or photos taken with such a lens; magazines with wildlife photos or wildlife stamps; glue; poster material.

Procedure

1. Set up three stations or learning centers in the classroom: one with kaleidoscopes (the kind you

Age: Grades K—6
Subjects: Science, Language Arts, Art
Skills: analysis, application, classification, comparing similarities and differences, description, discussion, generalization, inference, invention, kinesthetic concept development, media construction, observation, psychomotor development, small group work, synthesis
Duration: five—ten minutes or longer at each learning center; 30 minutes for discussion and posters
Group Size: one or two students at a time at learning centers; any size group in summary activity
Setting: indoors, at learning centers
Conceptual Framework Reference: III.D., III.D.1., III.D.2.
Key Vocabulary: adaptation, vision, kaleidoscope, binocular, fish-eye lens

can see through); the second with either binoculars or telescopes; and the third with a fish-eye mirror (or photos of objects taken with a fish-eye lens on a camera).

2. Have the students visit each station, trying out the different kinds of vision. (Younger students may require assistance in using the equipment.)

3. Ask the students to guess what kinds of animals might have each of these three types of vision, emphasizing that the way an animal sees is a form of adaptation. Adaptation is something animals have in order to survive in an environment. For example:

Binoculars—Predatory birds (eagles, hawks, owls) have acute distant and depth of vision similar to telescopic vision. They do not have tunnel vision, however, as a telescope might suggest; they have exceptional peripheral vision. This allows them to see their prey from great distances.

Kaleidoscopes—Insects have compound eyes. Each facet of their eye functions like a separate eye and allows them extreme peripheral vision. This allows them to detect predators.

Fish-eye mirror or photos—Fish have eyes with wide-angle perception. They can see predators, prey, and other food sources.

4. Divide the class into three groups and have each group cut out magazine pictures and make a poster for one of the three stations, showing the kinds of animals that have that particular kind of vision.

Extensions and Variations

1. Have students write a paragraph with the title, "I'd like to see like a ____________", in which they could describe how they would see things and why they would like to be able to see that way. They could also describe what that animal's view of the world would be like.

2. Students could make eyeglasses, and—by drawing or cutting out magazine photos—show the colors, shapes, or patterns of an animal's eye. Or, they could create a small collage showing what that animal's view of the world would be. The art work occupies the space on the eyeglasses where the lens would normally be. Unlined tagboard paper is thin enough to cut out eyeglass shapes without tearing easily.

Evaluation

Each of the following animals has either **kaleidoscope, binocular, or fish-eye mirror eyes:** trout, owl, fly, eagle, cricket. Identify which kind of vision each animal has.

How do the eyes of eagles help them to hunt better?

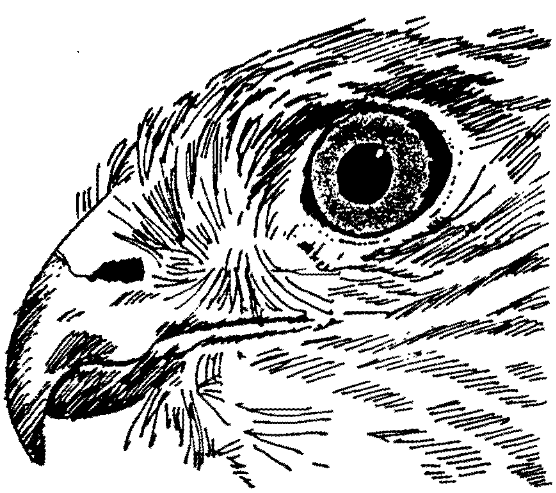
Birds are unique. They have special body parts that set them apart from all other animals. In this demonstration/activity, your kids can learn about some of these special avian features as you discuss each one.

DEMONSTRATION #1: FOWL BALL

Ask the group if they think birds have good vision. Then draw an outline of a bird's head on the board or on a large piece of easel paper. Ask if a bird's eyes are located more on the sides of the head or on the front of the head. (In most birds, the eyes are on the side. But in some owls and hawks, the eyes face forward.) Then have someone come up and draw in the bird's eyes.

Next have each person look at his or her neighbor to see where human eyes are located. (They face forward.) Explain that people have *binocular vision*, which means both eyes focus on the same image. Most birds have *monocular vision* most of the time because each eye focuses on a different image. Most birds have binocular vision only when they focus straight ahead with both eyes focused on the same image.

Then have each person gently shut one eye or cover one eye with a hand and look around. Ask if they can tell a difference between one-eyed sight and two-eyed sight. (Animals with binocular vision can judge



distance better than those with monocular vision.)

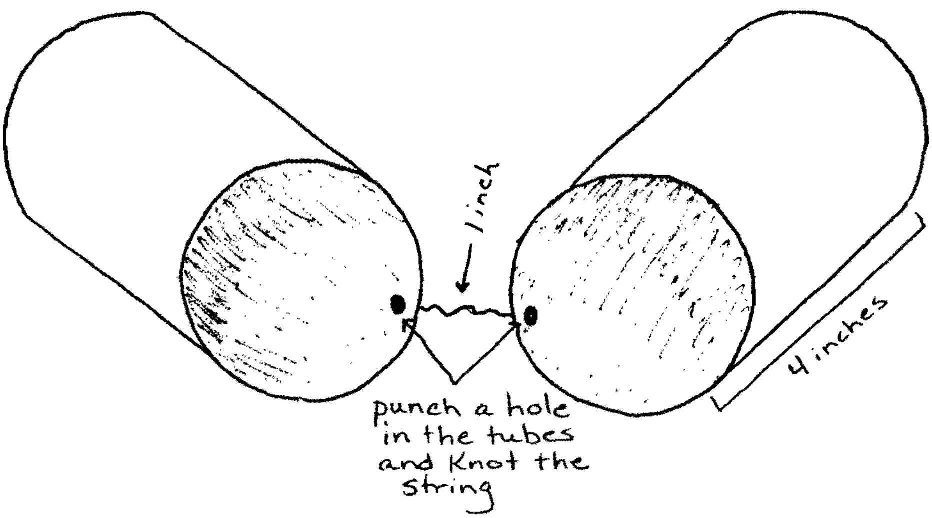
To demonstrate the difference, have everyone make an eye patch using a piece of black construction paper stapled to an elastic band. Take the group outside and have everyone put on his or her eye patch. Then make a large circle and play catch. Is it any harder to catch a ball when seeing out of only one eye?

Wolves and Rabbits

Project: Have students "make" a pair of eyes to demonstrate the differences between vision of a wolf (predator) and a rabbit (prey).

Materials:
1) cardboard tubes
2) string
3) scissors
4) pictures of wolves and rabbits

Design:

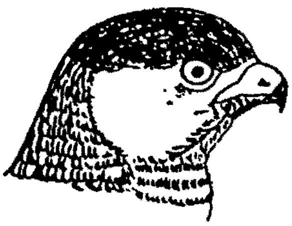


Activity:

1) Observe the pictures of wolves and rabbits. Note the difference in eye placement of predators and prey. Predators usually have forward-facing eyes and prey usually have side-facing eyes.
2) Have the students hold the "eyes" up to their own eyes and look through the tubes.
3) To see as wolves do, students hold the tubes together and look through them.
4) Have the students look to the left or to the right. They should have to turn their heads to do so. Predators (human included) can only see so far to the sides without turning their head. This frontal vision allows predators to focus on prey.
5) To see as rabbits do, students hold the tubes apart and look through them.
6) Have the students try to focus on an object to the left or right of them. Prey can't look directly at the object, they won't be able to see it. When students do look at the object, they should only be able to see it out of one tube or "eye." Prey have wide-angle vision, allowing them to see predators approaching from the sides; to eat and still see predators approaching from the sides.

DIFFERENCES IN BIRDS

If you look closely at the beaks of birds you will notice that there is a great difference in the size and shape of their beaks. Some birds have rounded, blunt beaks, while others have slender pointed beaks. These differences in birds are called adaptive features. Thousands of years ago birds began to spread out as they moved from place to place in search of new kinds of food. Gradually, they developed physical characteristics best suited to obtain the food found in their new home sites. The strong hooked beak of the parrot family is an adaptive feature which these birds use to get at the grubs and fruit which make up their diet.



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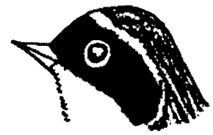
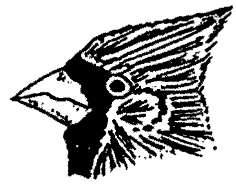


6.

The downy woodpecker has a sharp pointed beak that is used much like a chisel or ice pick in searching out insects in the bark of trees. The red-tailed hawk has the heavy beak of a bird of prey. Its razor-sharp point can easily rip through the hide of an animal and tear out pieces of flesh. Some water fowl have wide flat bills used for gathering aquatic plant materials and insects. Other water birds have long pointed beaks for spearing fish.



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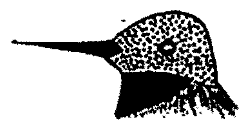

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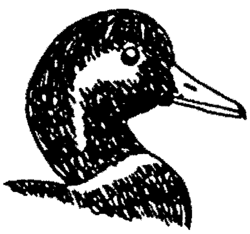

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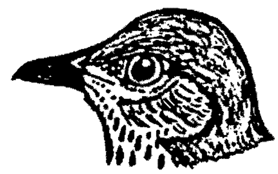
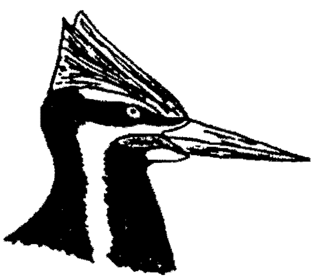


9.

Some of the birds found in your back yard have heavy beaks for crushing seeds, while others have modified beaks used for seed and insect eating. At least one bird has an elongated beak used for siphoning nectar out of flowers. Some birds have wide trap-like beaks for catching insects in flight.



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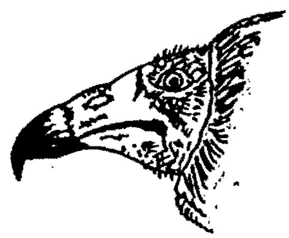
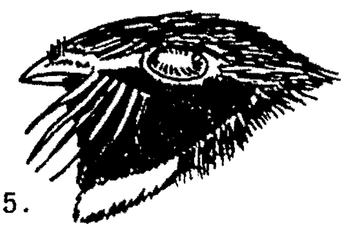


10.

Pictured on this page are several types of beaks which you probably have observed on birds in your area. Try to match the type of beak to the bird. Place the number of the beak type after the name of the bird.



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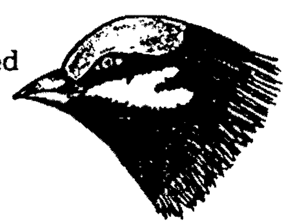


11.

Example: Robin 9

Wood Thrush ___	Martin ___	Great Blue Heron ___
Mallard Duck ___	Barn Owl ___	Pileated Woodpecker ___
Nighthawk ___	Cardinal ___	Hummingbird ___
Canada Goose ___	Vulture ___	English Sparrow ___
Kingfisher ___	Coopers Hawk ___	Yellow-Throat ___

Fill the Bill

Demonstrate some ways different beaks are adapted to getting different foods.

Objective:
Describe five different types of beaks and explain how each is adapted to feed on different foods.

Ages:
Intermediate and Advanced

Materials:
- ***copies of page 37***
- ***3 eyedroppers or straws***
- ***4 pairs of chopsticks***
- ***3 nutcrackers or pliers***
- ***2 large scoops or slotted spoons***
- ***3 strainers***
- ***3 envelopes or small fishnets***
- ***3 forceps or tweezers***
- ***3 tongs***
- ***small log***
- ***popcorn or tiny marshmallows***
- ***rice***
- ***puffed rice***
- ***2 aquariums or other large containers***
- ***fake worms or grapes***
- ***oatmeal***
- ***stemmed cherries***
- ***tall, thin vase***
- ***large saucepan***
- ***walnuts or other nuts***
- ***Styrofoam chunks***
- ***string***

Subject:
Science

It would be impossible for a hummingbird to gobble up a mouse. And it would be just as impossible for a hawk to slurp up some nectar from a flower. Each type of bird has a special beak and tongue adapted to eating a certain type of food. In this demonstration your group can find out which beaks are best for tearing, scooping, cracking, and picking by going to different stations you've set up and trying to find out which tools go with which types of "food."

First talk about some different bird beaks to get the kids thinking about how beaks help birds survive. Here are some examples of birds and beaks you can talk about:

- **Hummingbirds** have long hollow beaks that they use to probe flowers for nectar. The beak protects the tongue which slurps up the nectar.
- **Curlews, godwits, kiwis, and snipes** have very long beaks that they use to probe for worms, crustaceans, and other small creatures in mud and water.
- **Cardinals, sparrows, grosbeaks, and other finchlike birds** have very short, conical beaks. These beaks are very strong and can break open tough seeds.
- **Spoonbills and pelicans** have long, flattened or pouchlike beaks that they use to scoop up fish and other aquatic creatures.
- **Flamingos and some ducks** have bills that act like strainers to filter tiny plants and animals from the water. (Only certain kinds of ducks are filter feeders.)
- **Nighthawks, whip-poor-wills, swifts, and swallows** have large, gaping mouths that act like nets to trap insects. These birds catch insects on the wing.
- **Warblers** have small, sharp, pointed beaks for picking insects from leaves, logs, and twigs.
- **Toucans** have very long, thick beaks for reaching out and plucking fruit from trees.

Setting Up The Demonstrations

You'll need to set up eight different stations, each with a special type of "food" that fits one of the eight different types of beaks we've described. And at each station you will need three different tools—one that fits the food and two that don't fit so well. Also have a sign at each station that tells what type of food is represented. (For example, have a sign that says "nectar" at Station #1, one that says "worms in the mud" at Station #2, and so on.)

Here's a list of food and tools for each station. (The * indicates the tool that best fits the food.)

Station #1: Water in a tall, thin vase to represent nectar in a flower. (hummingbirds)
tools: eyedropper or straw*
envelope or small fishnet
large scoop or slotted spoon

Station #2: Large saucepan filled with dry oatmeal, with grapes on the bottom to represent worms buried in the mud. You can use fake rubber worms instead of grapes, if you can find some. (curlews, godwits, kiwis, and snipes)
tools: chopsticks*
nutcracker
strainer

Station #3: Whole walnuts or other nuts to represent seeds with hard coverings. (sparrows, cardinals, grosbeaks, and other finchlike birds)
tools: nutcracker or pliers*
tongs
chopsticks

Station #4: Styrofoam chunks floating in an aquarium filled with water to represent fish and other aquatic animals. (spoonbills and pelicans)
tools: large scoop or slotted spoon*
eyedropper or straw
chopsticks

(continued next page)

Station #5: Puffed rice in an aquarium filled with water to represent tiny aquatic plants and animals. (flamingos and some ducks)
tools: strainer*
forceps or tweezers
tongs

Station #6: Popcorn or tiny marshmallows tossed in the air (which must be caught while in the air) to represent flying insects. (nighthawks and whip-poor-wills)
tools: envelope or small fishnet*
forceps or tweezers
chopsticks

Station #7: Rice spread on a log to represent caterpillars and other insects. (warblers)
tools: forceps or tweezers*
envelope or small fishnet
nutcracker or pliers

Station #8: Cherries hanging from a string to represent fruit hanging from a branch. (toucans)
tools: tongs*
eyedropper or straw
strainer

Leonard Lee Rue III gannet

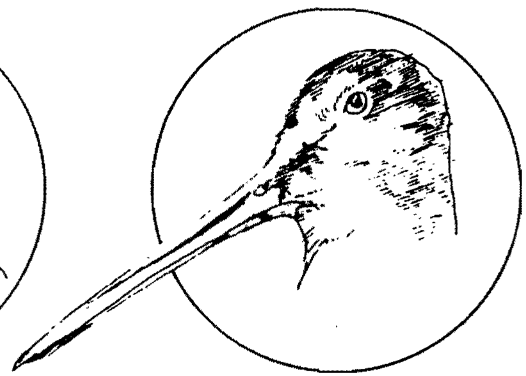
Doing The Demonstrations

Pass out a copy of page 37 to each person. Divide the group into eight teams and start each team at a different station. Explain that there will be three different tools at each station, each of which represents a different type of bird beak function. Each group must decide which tool would most efficiently get the food at each station. (They should decide by trying out the different tools.) Once they pick the best tool, they should write the name of the tool on their Copycat Pages in the appropriate square. (You might want to set a time limit at each station to keep things moving.) Underneath the squares are pictures of different birds and their beaks. On the line under each picture, they should write the number of the square that represents the correct beak. For example, they should write "8" on the line under the toucan.

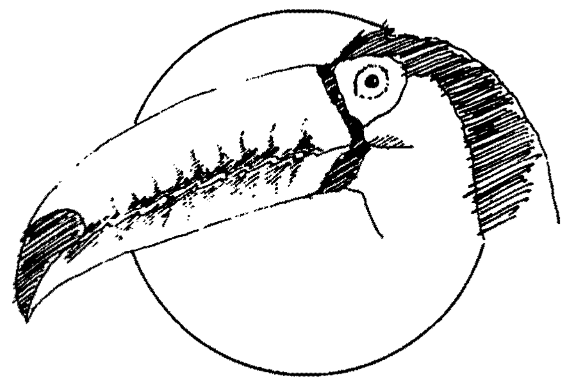
After the activity, discuss beak adaptations in general. Explain that many birds, after millions and millions of generations, have evolved very specialized beaks (beaks that can eat only one certain type of food). Ask the group how specialized beaks can help some birds stay alive. (A bird with a specialized beak can often eat a type of food that no other bird can eat.) Then ask how a specialized beak might hurt a bird. (If the bird's habitat changes and its food is no longer available, the bird might die because it can't eat anything else.) Explain that some birds, such as crows, have very versatile beaks. Crows can eat fruits, nuts, berries, dead animals, and even fish and small rodents. If one type of food is not available, they can always eat something else.

1 NECTAR	**2** WORMS IN THE MUD	**3** SEEDS	**4** FISH AND OTHER WATER ANIMALS
5 TINY WATER PLANTS AND WATER ANIMALS	**6** FLYING INSECTS	**7** CATERPILLARS AND OTHER INSECTS	**8** FRUIT

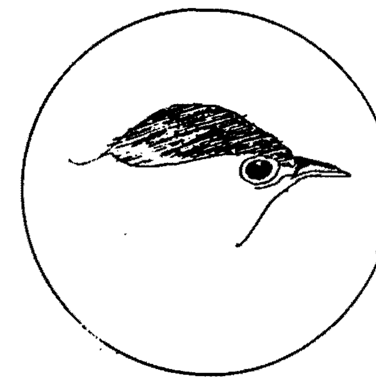
WHIP-POOR-WILL ____



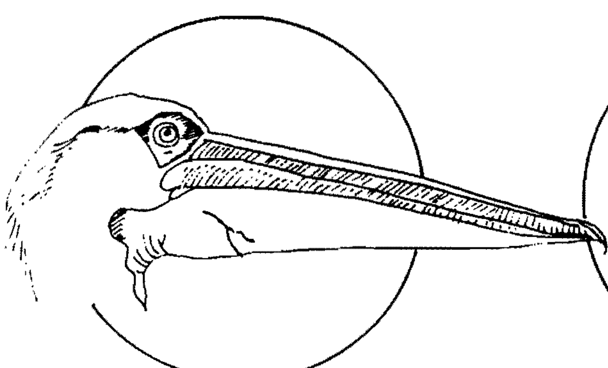
SNIPE ____



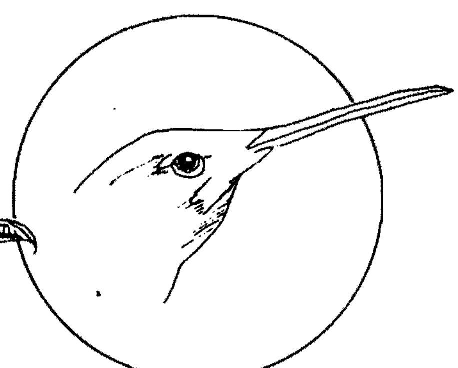
TOUCAN ____



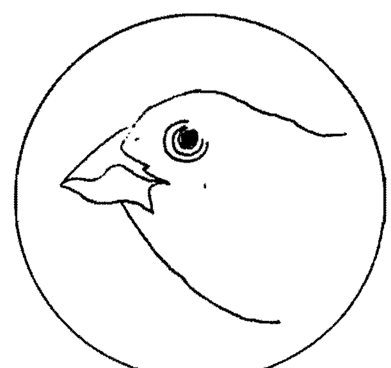
WARBLER ____



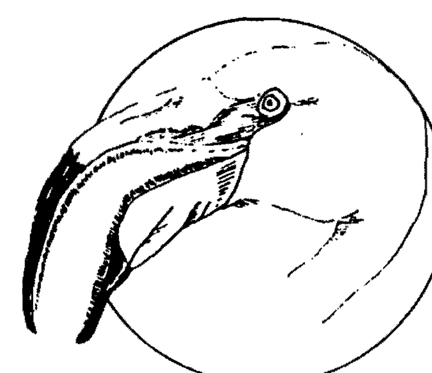
PELICAN ____



HUMMINGBIRD ____



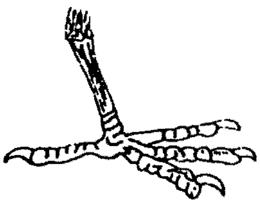
GROSBEAK ____



FLAMINGO ____

DIFFERENCES IN BIRDS

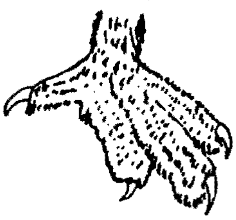
If you were to see only the feet of a bird, could you identify the type of birds that possess such feet? There are differences in the feet of birds, which serve the birds for specialized uses. Birds of prey have feet that are used for seizing and holding their prey. Birds of prey do not always kill with their beaks. Hawks pierce the heart or lungs of their prey with their sharp heavy claws, and usually kill instantly. Their legs are so strong that they can fly miles to their nests with an animal as large as a young rabbit clutched in their claws.



1. Perching

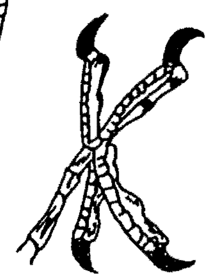
5. Grasping

The duck-hawk will dive upon ducks in flight. Striking with extended legs and closed talons, the ducks are instantly killed or knocked unconscious by the force of the blow.

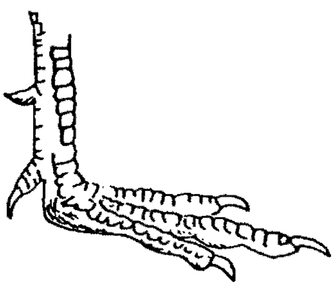


2. Snowshoe

Water birds that dive have developed webbed feet for paddling under the water. Their legs are set further back on their bodies than the legs of most land birds. This enables them to tip their bodies forward into the water easily. This unusual leg structure is the reason for the various waddling walk of ducks.

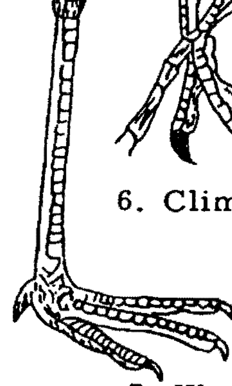


6. Climbing



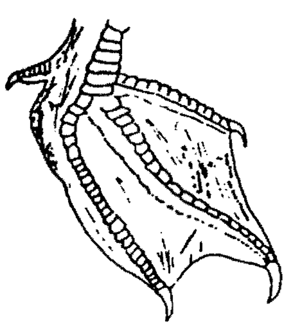
3. Walking

A modified web-foot is possessed by some water birds. They may run along the mud or swim in the water with equal ease.

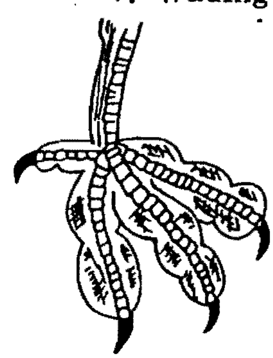


7. Wading

There are many other examples of the use of specialized feet in the bird world. Look at the different types of feet pictured on this page. You will probably be familiar with all types with the exception of one. With this one, the SNOWSHOE, you will have to do a little detective work.



4. Swimming



8. Swimming and Walking

Listed below are the names of several birds which have different types of feet. Write the number of the foot type after the bird named, and see if you can fit the foot!

Example: Robin 1

Mallard duck	___	Downy Woodpecker	___	Flicker	___
Red-Tailed Hawk	___	Bob White Quail	___	Sparrow	___
Coot	___	Great Blue Heron	___	Ptarmigan	___
Cardinal	___	Canada Goose	___	Barn Owl	___

Feet Are Neat

Match birds to their feet and mold bird feet out of clay.

Objective:
Describe several types of bird feet and explain how each helps a bird survive in its habitat.

Ages:
Primary and Intermediate

Materials:
- *copies of page 39*
- *clay or modeling dough*
- *pipe cleaners*
- *tape*
- *markers, crayons, or colored pencils*
- *white cardboard or stiff white paper*

Subjects:
Science and Art

One good way for kids to understand how birds are adapted to live in their habitats is for them to take a look at bird feet. Since different types of birds use their feet in different ways, bird feet come in a lot of different shapes and sizes.

Ask your group to think of some of the ways birds use their feet. (They use them for walking, perching, swimming, running, climbing, and grabbing.) Then talk about some of the different kinds of feet different birds have. Here are some examples:

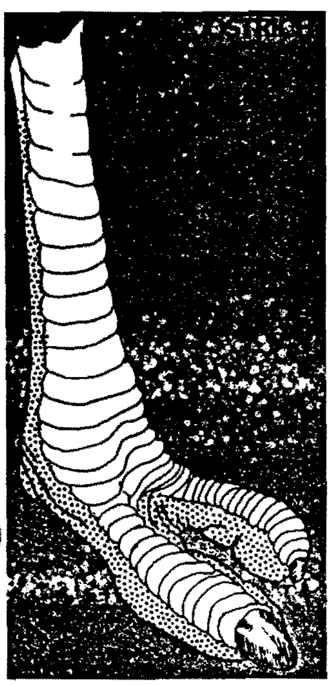
- Climbers—Woodpeckers have two toes in front and two toes in back for climbing up and down tree trunks.
- Graspers—Hawks, owls, and other birds of prey have large curved claws, called *talons*, that dig into their prey and help them hold onto it in flight.
- Perchers—Robins, mourning doves, and many other birds have three toes that face forward and one long hind toe that helps them grip their perches tightly.
- Runners—Ostriches and killdeer have two and three toes, respectively (instead of four), and all their toes point forward for fast running.
- Scratchers—Pheasants, chickens, and other chickenlike birds have rakelike toes for scratching in the soil.
- Swimmers—Ducks, coots, and other swimmers use their feet as paddles.

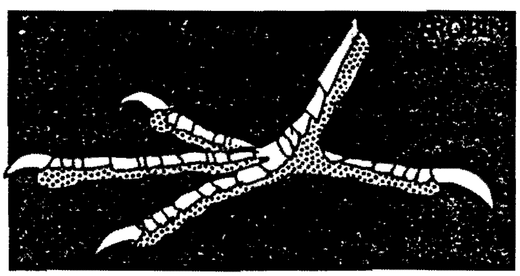
Next pass out copies of page 39 to the group and have them try to figure out which birds go with which feet. Then pass out lumps of clay or modeling dough and have everyone make a model of bird feet. (They can each pick one of the birds on the Copycat Page or they can pick different birds.) When they're finished, have each person draw a picture of his or her bird on a piece of white cardboard or stiff white paper, color it, and tape pipe cleaner legs to the cardboard. (To make each leg, have them twist two pipe cleaners together.) Then they can push the legs, with the bodies attached, down into the feet.

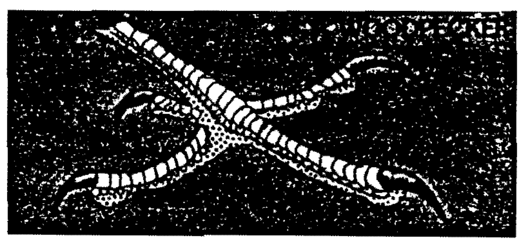
Branching Out: Take A Hike

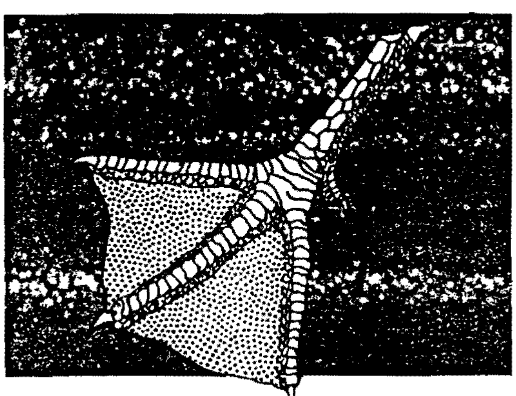
Take your group on a bird walk to look at different kinds of bird feet. Each time you spot a bird, talk about its feet. Ask the kids if the bird is a climber, a swimmer, a runner, a walker, a predator, or a "perching" bird.

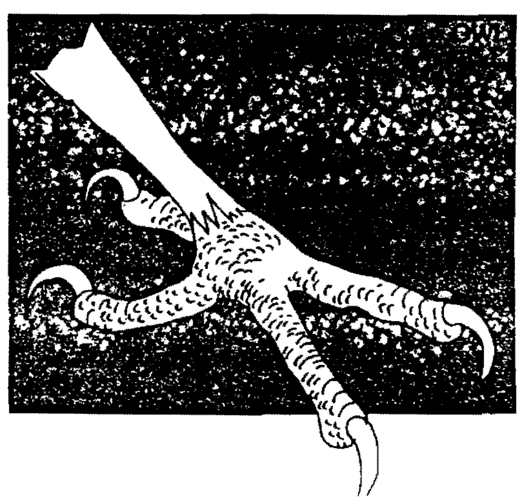
While you're out walking, you can also look at bird beaks. See "Fill the Bill" on page 29 for information about different kinds of bird beaks and what they do.



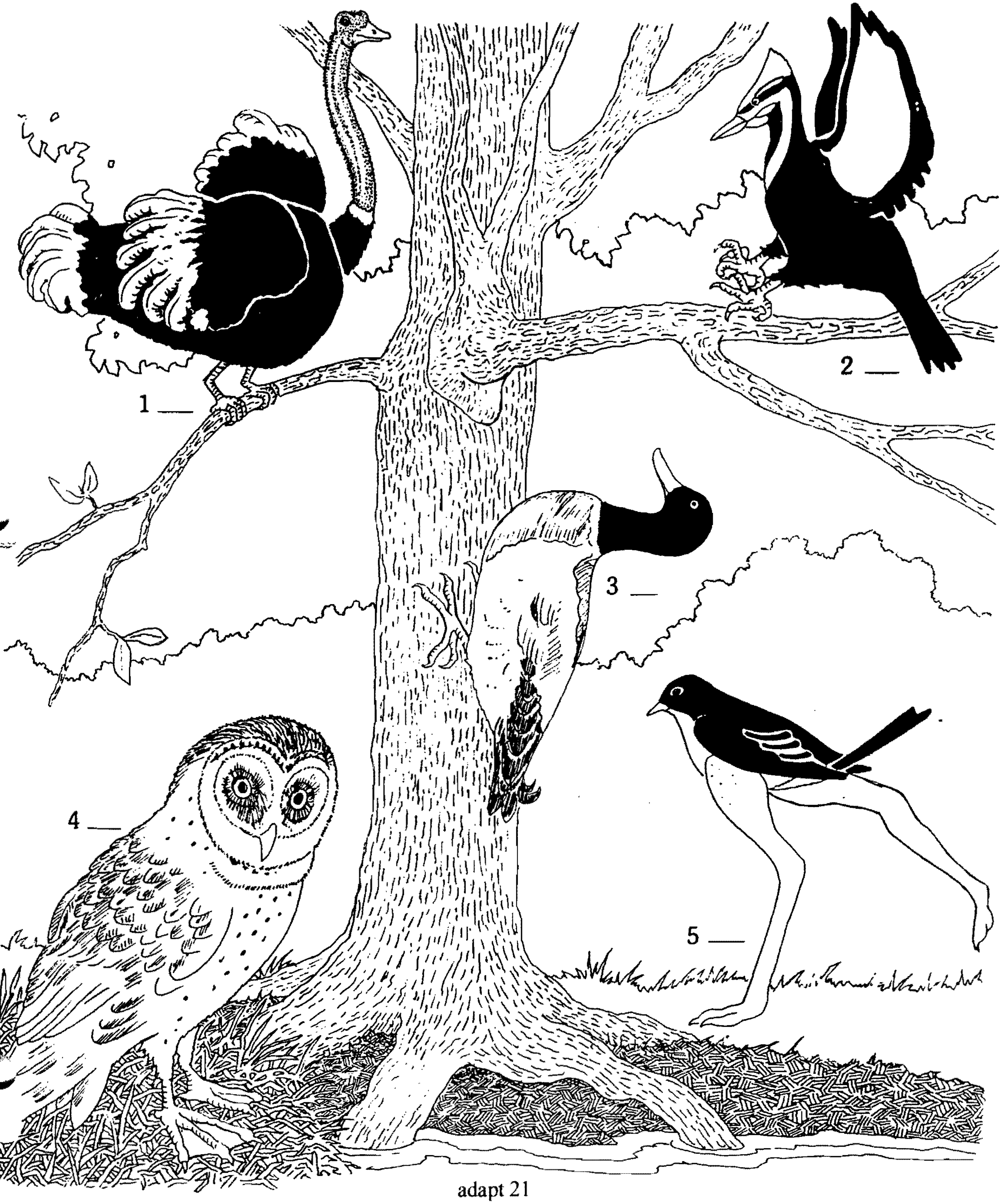








These birds all have the wrong feet! In the blank next to each bird, write the number that represents the "right" feet.



BAT INFORMATION

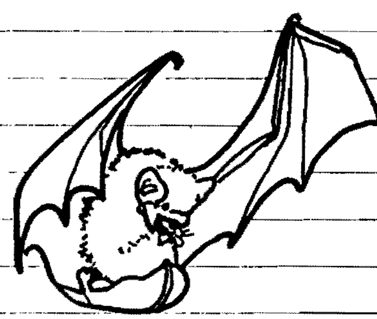
Bats are unique animals.

- They are the only mammals that are true fliers.
- They have specialized wings that are made of tough skin and have "fingers" that spread and support the wings. The skeleton and soft anatomy in the wing of a bat may be directly compared to the arm and hand of a human.
- Bats live on all continents except Antarctica.
- They make up nearly one quarter of all mammals on earth. There are nearly 1,000 species of bats.

Due to their uniqueness, scientists have placed bats in a mammal group of their own called chiroptera, meaning "hand-wing." All bat species belong to one of two main groups, megachiroptera (megabat) or microchiroptera (microbat).

Megabats are fruit-eating bats that live in tropical areas. They are larger in size than the microbats with some having wing spans of nearly six feet. Often megabats are referred to as "flying foxes" because their facial characteristics resemble those of foxes. Megabats have large eyes and do not depend on echolocation to fly or find food.

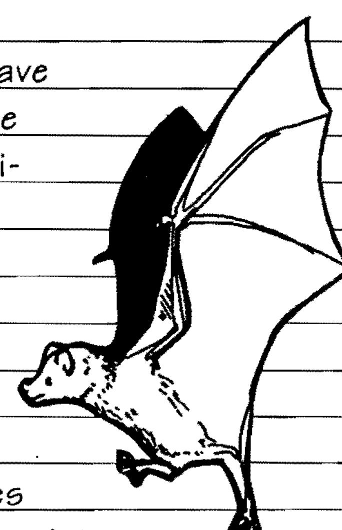
There are nearly 800 species of microbats, forty-two of which live in the United States and Canada. All North American bats are microbats. Microbats are small in size, ranging from the smallest known mammal, the bumblebee bat of Thailand which weighs less than a penny, to as much as eight ounces. Most North American bats range in weight from one quarter ounce to one ounce. Microbats eat mainly insects, but this group also includes several species that lap blood, a species that catches frogs, one that scoops fish out of the water, and some that catch birds and rats. Microbats can see with their small eyes, but most rely upon the use of echolocation to help navigate at night and to catch their food.



Flight Facts

Bats belong to the order Chiroptera which comes from the Greek words *cheiro* meaning hand and *ptera* meaning wing. Together the words suggest hand-wings, a characteristic which makes bats easily distinguishable from birds. (The word *bat* itself comes from the Danish word *blaka*, meaning to flutter or flap.)

The wing of a bat looks like a cross between a duck's webbed foot and an umbrella. It is made of a tough leathery interfemoral membrane that stretches between four long struts, or bat fingers and attaches to the back legs. For some bats, the membrane is stretched between the hind legs and tail producing a rudder-like tail. The wing spans of the approximately 1,000 species of bats vary from less than one inch to six feet.



Birds are stronger fliers than bats, but bats have more flexibility and control because of their unique wing structure which allows them to move the individual bones in their wings. Highly complex changes in the shape of the wings can be made very rapidly permitting the bat great maneuverability. The inner fingers of the bat's wing act primarily as a lifting airfoil to counteract gravity, while the outer fingers provide thrust to propel the bat forward. Bats have powerful chest muscles to drive the wings with enough force to achieve a variety of maneuvers. The harder the wings are flapped, the greater the force produced, resulting in greater speed. The rate of wing flapping varies greatly: Large bats may flap their wings up to 20 times per minute, while small bats flap their wings up to about 16 times per second.

Inside a Bat

Topic Area
Bat anatomy: wing structure

Introductory Statement
Students will use toothpicks to construct a simplified model of the wing structure of a bat.

Math
Using a symmetrical pattern

Science
Life science
bat wing structure

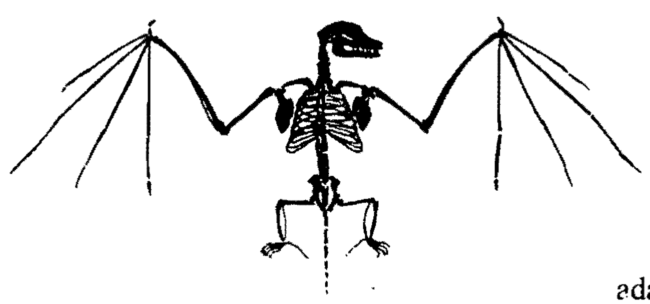
Math/Science Processes
Observing
Comparing
Classifying

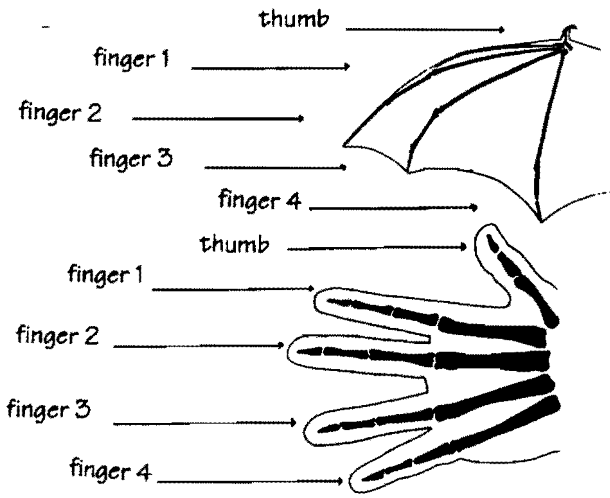
Materials
Day 1
For the teacher:
finished model of bat wings with toothpicks
or transparency of *Page 4*
For each group:
white glue
tagboard pattern *(Page 3)*
For each student:
1 - 9 x 12" piece of black or brown construction paper
1 - 9 x 12" piece of another color construction paper (for background)
12 toothpicks

Day 2
For the teacher:
transparency of *Page 1*
For each student:
copy of *Page 1*
optional: copy of *Page 2*

Key Question
How is a bat's wing like a human hand?

Background Information
A bat is the only mammal that can fly. The wings of a bat are actually modified arms. The bones in a bat's wing are like the bones in a human arm and hand except that a bat has very long fingers. The front edge of the wing is supported by the upper arm, forearm, and second and third fingers. The rest of the wing is supported by the fourth and fifth fingers. A bat's wing has two thin layers of flexible skin stretched between these fingers. The skin is so thin you can almost see through it. The thumb of a bat is like a claw; it is used to help the bat move across rough surfaces of cave walls or tree bark.





Management
1. This activity is best done in two days.
2. It will take about 30 - 45 minutes for each of the two parts.
3. This activity may be done in small groups or as a whole class.
4. Beforehand, cut out the tagboard patterns; you need one per group.
5. Have a transparency of the bat skeleton to show students the placement of the toothpick "bones" (see *Procedure*).

Procedure
Day 1 - Skeleton of bat wings
1. Ask the *Key Question:* "How is a bat's wing like a human hand?" to assess what students already know. Let them share ideas and guesses.
2. Explain to students that they will be doing an activity that will allow them to discover many similarities between a hand and a bat's wing. Divide into groups.
3. Give students black or brown construction paper.
4. Fold the construction paper in half.
5. Show students the bat pattern. Since the pattern is of only half a bat, ask what will happen when the pattern is placed on the fold of their construction

paper, traced around, and cut out. Let students share guesses.
6. Explain that a bat skeleton, like a human skeleton, is generally symmetrical. If a picture of a bat is divided in half, that half will be a mirror image of the other. When the paper bat is unfolded, the two sides should look symmetrical.
7. Pass out tagboard bat patterns. Have students place the pattern on the fold of their construction paper, trace, and cut out.
8. Have students observe the fold as the *line of symmetry* that divides the bat in half.
9. Pass out toothpicks.
10. Explain that because a bat is symmetrical, it will usually have the same number of bones on both sides and the bones will be in approximately the same locations.
11. Explain that a bat has many more bones in its body than are being used. The toothpicks represent some of the bones in the wings.
12. Distribute the second sheet of construction paper. Glue bats to this background piece.
13. Have the students place the toothpicks on the paper where the arms and fingers are located. Have children refer to the teacher's transparency to self-correct; then glue toothpicks to bats.
14. Have students draw on additional features like eyes, nose, feet, etc.

Day 2 - Comparison of bat wing to human hand
1. Explain that yesterday they used toothpicks to show where the bones are in the wing of a bat; today they will draw the bones of a bat wing and a human hand to see how the two bone structures are alike and how they are different from one another.
2. Distribute copies of *Inside A Bat*. Two options are given for this handout. Your selection depends on the ability level of your students. One handout allows the students to draw the bones in the bat's wing and the human hand. Demonstrate this procedure. The other, a more simplified version, has the bones already drawn in for the students to compare and contrast.
3. Have children label the thumb and fingers.
4. Discuss similarities and differences. [similarities: same number of fingers, flexible fingers, skin covering; differences: bat's hand used to fly, longer fingers, almost transparent skin, etc.]
5. Have students record similarities and differences.

Discussion
1. What does it mean when something is symmetrical?
2. Describe where a bat's thumb is located.
3. How many fingers does a bat have?
4. Explain how the human hand and the bat's wing are alike.
5. Explain how the human hand and the bat's wing are different.

Extensions
1. Have students do a whole bat skeleton, including leg bones, ribs, and spine, using reference books and the drawing at the top of *Page 3*.
2. Have students trace around one of their own hands and glue toothpicks on the tracing for the bones in their fingers.
3. Explore and discuss symmetry. Identify whether or not various classroom objects are symmetrical. Find animals besides bats that are generally symmetrical in outer appearance or skeleton.
4. Find out more about bats, especially what they eat and where they live.
5. See if there is a bat habitat near your school. Visit it if possible.

Curriculum Correlations

Language Arts:
1. Write a poem about a bat.
2. Research what other animals have that is comparable in use to a bat's wing": whale's fluke, animals' hoof, paw, etc.

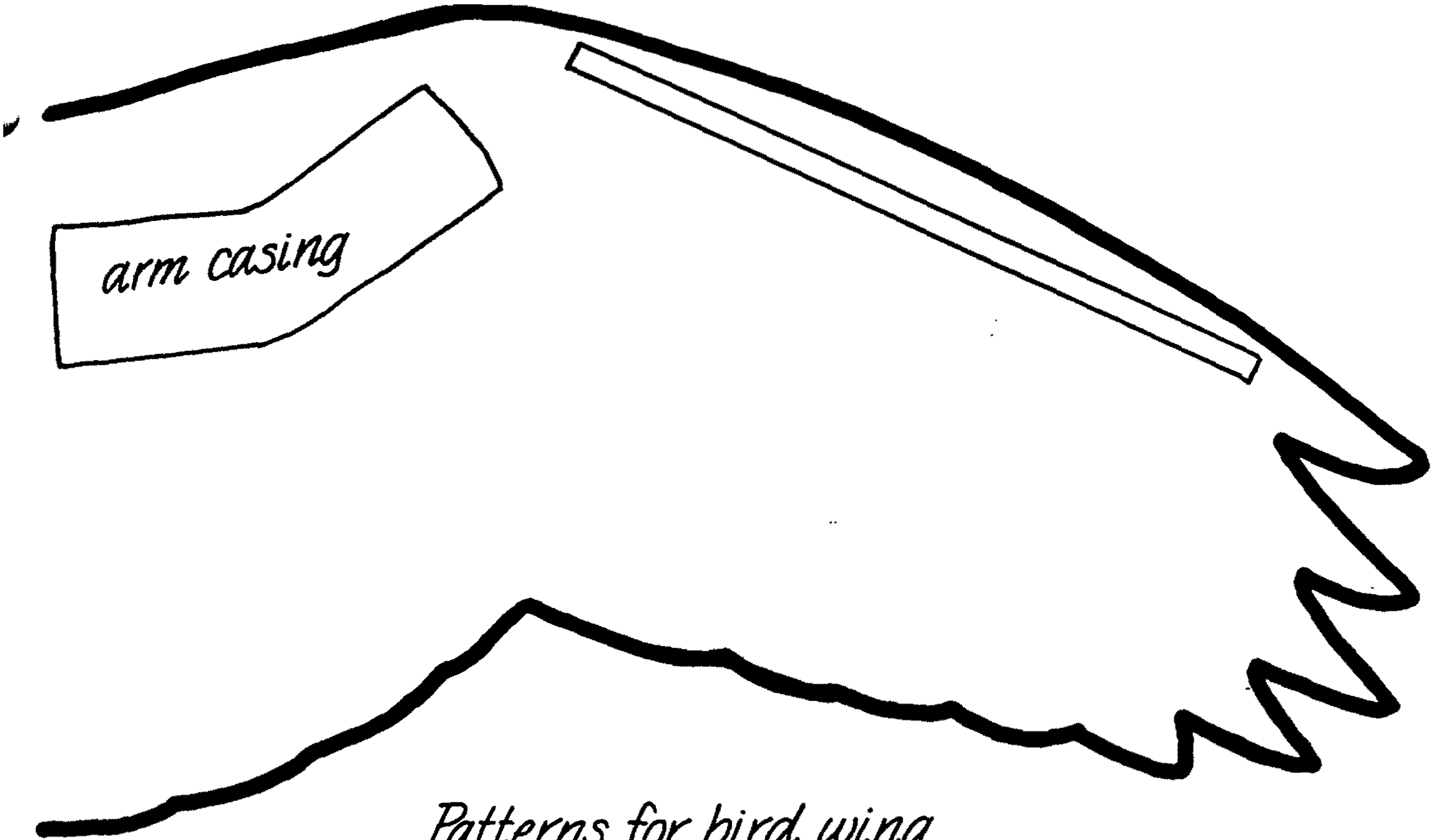
Social Studies:

Ask friends and relatives for their opinions of bats; see if they can explain why they have these ideas. Are they based on factual information?

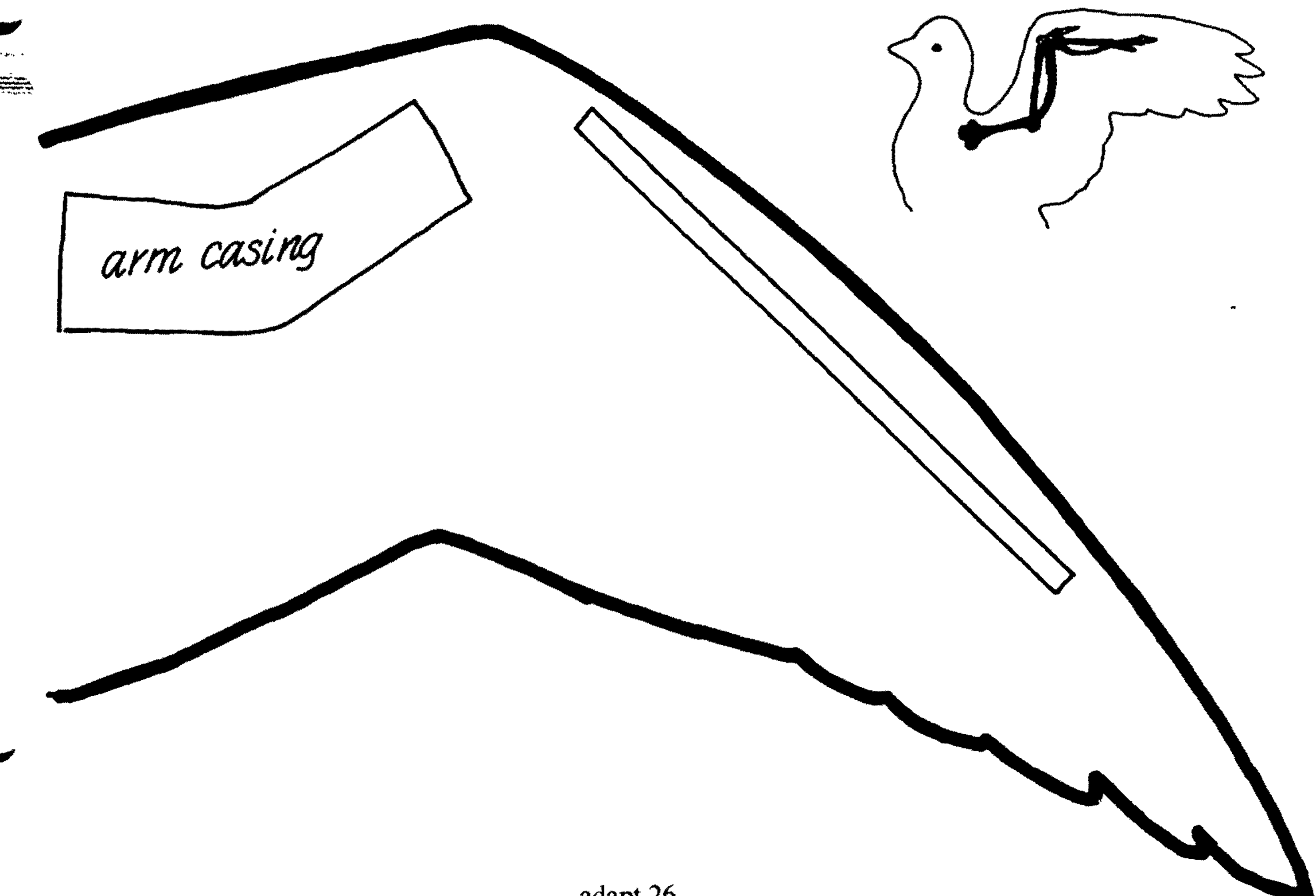
Art:

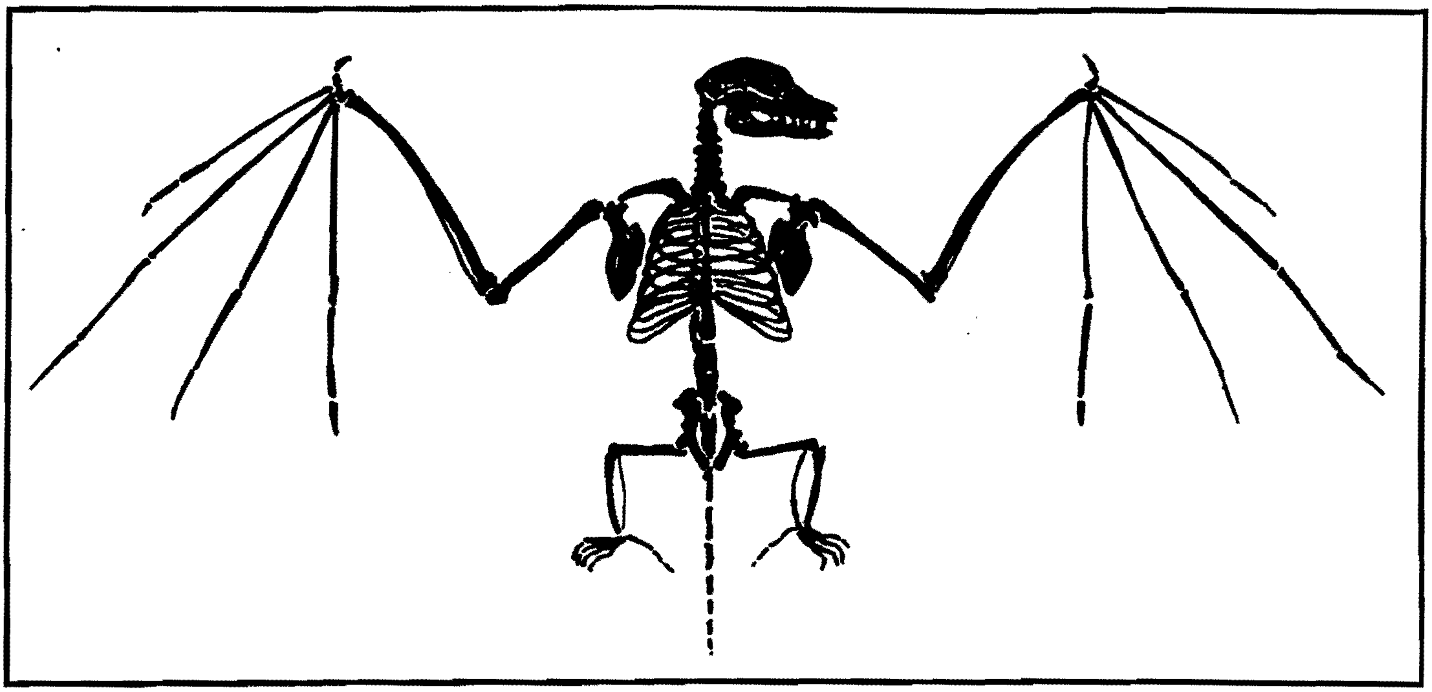
Have students explore the symmetry of their faces. First, they fold a paper in half and use mirrors to draw one half of their own faces. Then duplicate this first half (reversed) on the other half of the paper. By using the mirror again, they can observe how much the two halves of their faces are symmetrical and in what respects they are asymmetrical.

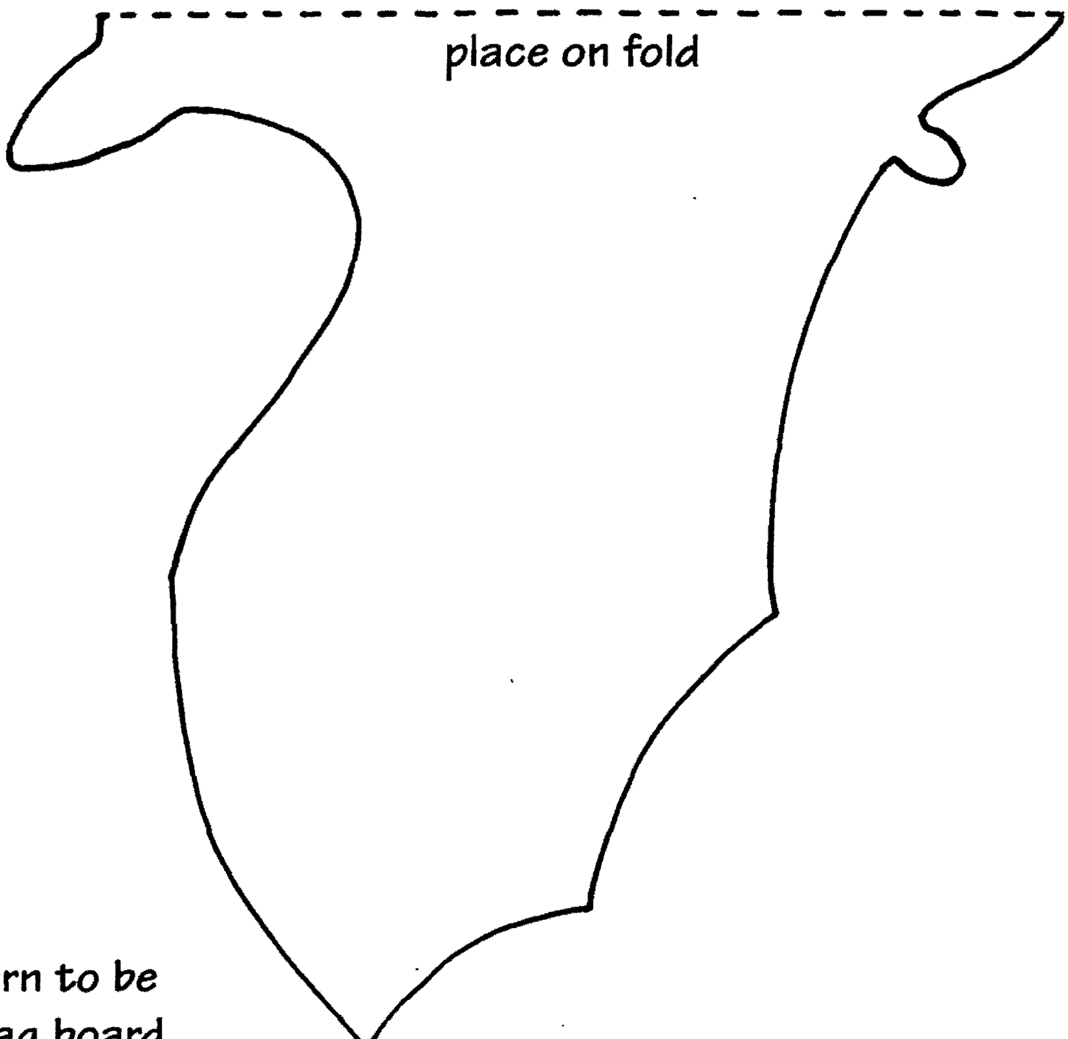
Major Conceptual Components
- Bats live in diverse habitats where their unique structures allow them to meet their basic needs.
- Bats have unique structures which allow them to meet their basic needs.
- A bat's wing allows flexible and effective flight.
- A bat's wing can be compared to the human hand and arm.



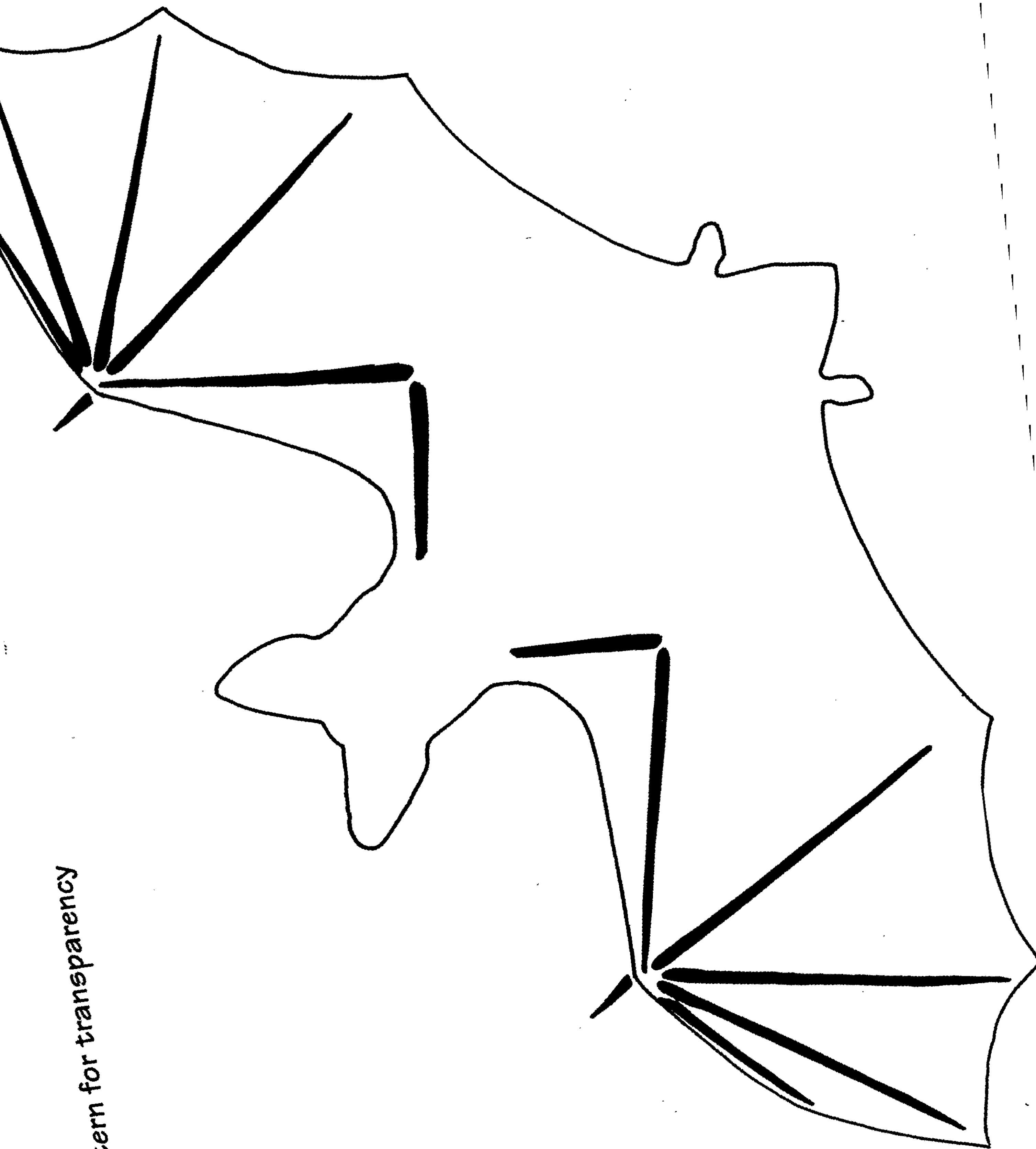
Patterns for bird wing





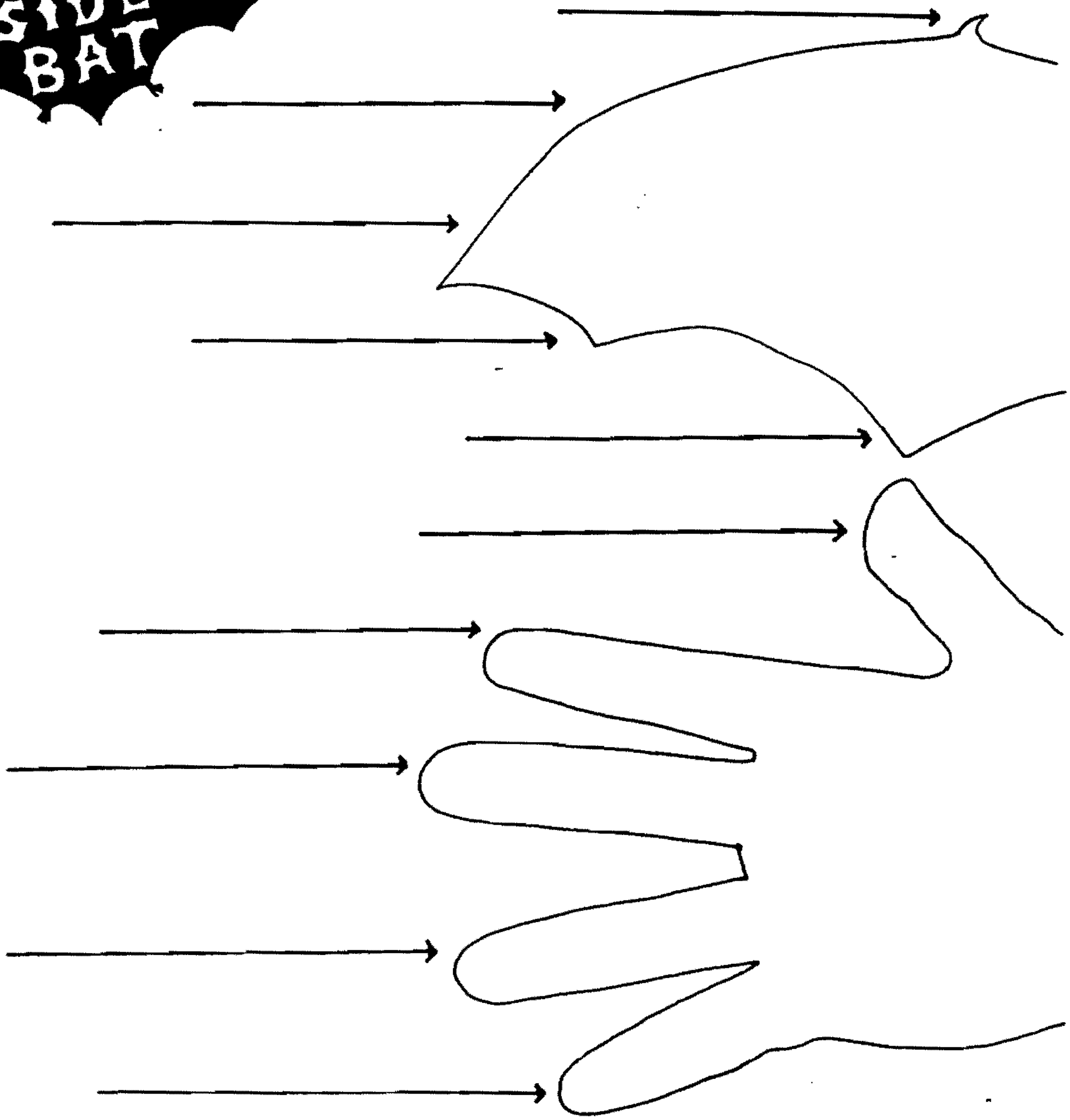


Bat pattern to be made of tag board



Pattern for transparency

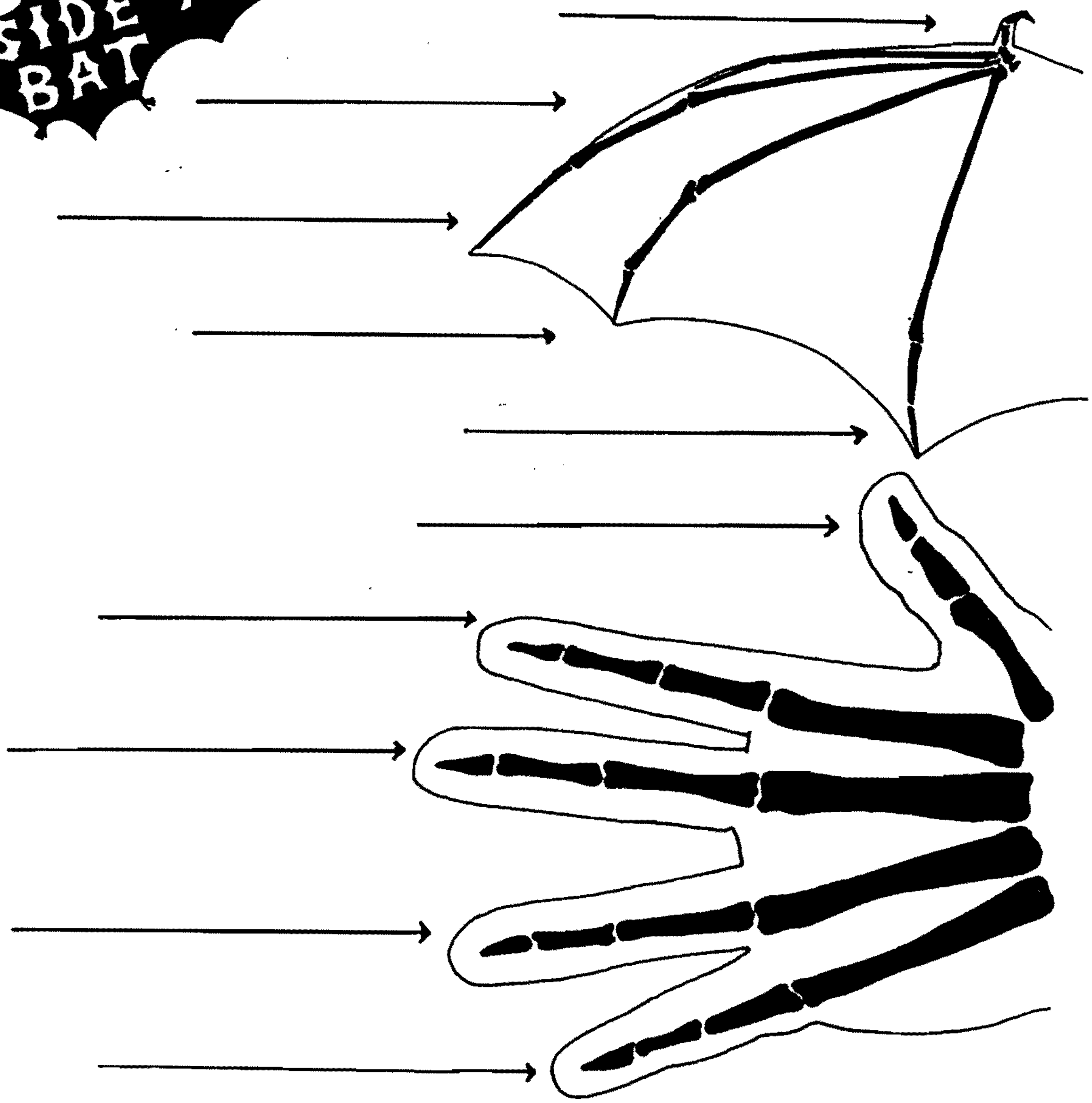
Name



How were they alike?

How were they different?

Name ______________________________



How were they alike?

____

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How were they different?

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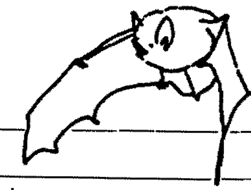
Echolocation
Locating by Echoes



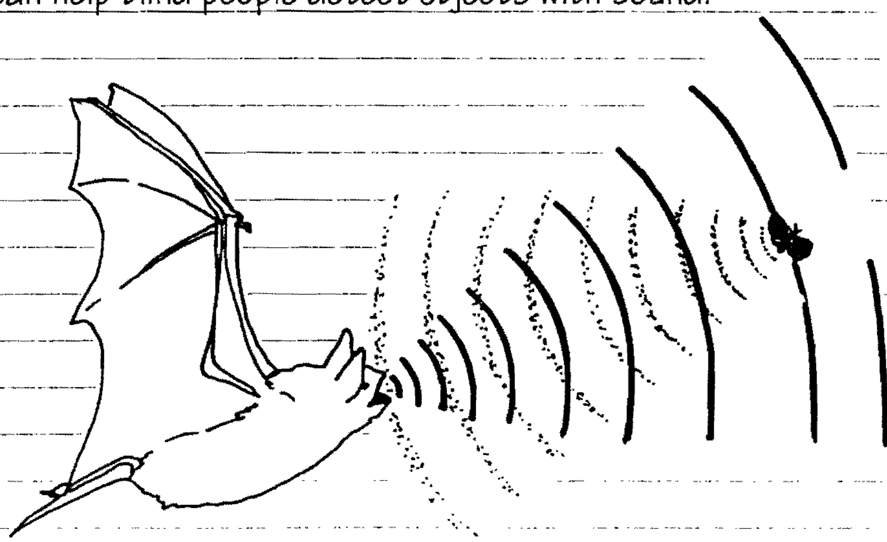
Echolocation is a method of sensory perception by which certain animals orient themselves to their surroundings, detect obstacles, communicate with others, and find food. In echolocation a series of short, high-pitched sounds are emitted by an animal. These sounds travel out away from the animal and then bounce off objects and surfaces in the animal's path creating an echo. The echo returns to the animal, giving it a sense about what is in its path.

Echolocation is used by most microbats. Each species of microbat that uses echolocation has its own unique sound that is produced in the voice box. The frequencies of these sounds extend beyond the range of human hearing. One species of megabat, the Egyptian Fruit Bat, uses tongue clicks to echolocate.

The sounds are emitted in short pulses which are repeated at varying rates. These rates vary from one pulse per second to several hundred per second when a bat is close to a target. By listening to and analyzing the echoes from these pulses, a bat can determine an object's size, shape, direction, distance, and motion. This echolocation system is so accurate that bats can detect insects the size of gnats and objects as fine as a human hair.

Most echolocating bats appear to emit signals through their opened mouths. Knowing this helps to explain why many photographs of bats show them in flight with their mouths open. Other species emit their signals through their nostrils. These bats fly with their mouths closed but usually have elaborate facial characteristics such as nose leaves which help direct the sound pulses.

Scientists would like to know more about how bats use echolocation so they can help blind people detect objects with sound.



Sensational Ears

Topic Area
Echolocation

Introductory Statement
In this simulation activity, students will attempt to catch a moving object using only their sense of hearing.

Science
Life science
- adaptations

Math/Science Processes
Observing
Predicting
Comparing and contrasting
Generalizing
Communicating

Materials
For each group:
- lid from paper box (see *Management*)
- marble

For each student:
- bat ears
- a 5-ounce paper cup

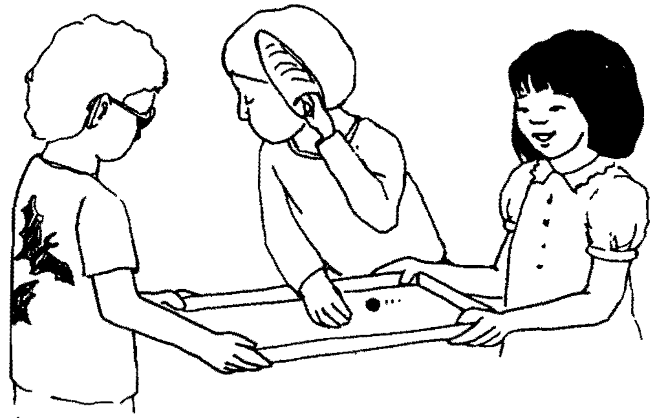
Key Question
How can an insect-eating bat catch its prey using only its sense of hearing?

Background Information
Insect-eating bats locate their prey utilizing echolocation. They emit sounds from their mouths and noses. These sounds bounce back as echoes. The bats' sensitive hearing allows them to hear variations in pitch which help them locate their prey. Echolocation enables the bats to figure the speed and direction the insects are flying. Some bats which use echolocation also have other body adaptations which enable them to use their wings and tail to scoop up insects and place them into their mouths while flying.

In this simulation, the students cannot use echoes to locate a moving object; they can, however, use the actual sounds made as an object moves to attempt to locate it while they have their eyes closed.

Management
1. Copy-paper box lids, cardboard trays, or other shallow boxes are suitable for use in this activity.
2. The students should not be able to see the marble roll in this activity. Blindfolds interfere with the student's hearing and the bat-ear placement. It is easiest just to ask the student who is designated the "bat" to close his or her eyes.
3. Students in small groups of three or four will be assigned jobs and the jobs will be rotated after each turn. The "bat" (with eyes closed) will attempt to catch the marble as it is rolled gently across the bottom of the box lid. The two other students will be assigned as "movers." They should each take one end of the box lid and gently raise and lower the ends to make the marble roll. In groups of four, the fourth person will be the observer to check that the rules are followed for snatching the marble.
4. It must be emphasized that the "bat" must quickly snatch at the marble and use only the fingers and thumb of one hand (not the palm of the hand or the arm) when attempting to catch the marble.
5. Allow about 15-20 minutes to complete this activity.
6. Bat ears are most effective and durable if copied on card stock or tag. Prior to the activity students should cut out the front and back of the ear. The front and back part of the ear should be glued around the perimeter leaving an opening where indicated.
7. Prior to the activity, the teacher should gather the box lids, marbles, and duplicate the bat ears for each student.

Procedure
1. Ask the *Key Question:* How can an insect-eating bat catch its prey using only its sense of hearing?
2. Direct students to think about whether it would be hard to catch something they could not see. Show them a box lid and marble. Roll the marble in the box lid and ask students if they can hear it. Tell them that the person chosen to be the "bat" will have to close his or her eyes so the marble cannot be seen. Demonstrate how to use the bat ears by sliding the hand into the ear like a mitt. The hand will cup the back of their ear. Because the student will have to rely upon the sense of hearing, "bat ears" supported by the cupped hand will help to funnel the sound.



3. Distribute the box lid, marbles, and bat ears to each group.

4. Have students choose jobs.
5. Without closing their eyes, let students practice catching the marbles by snatching them with their thumbs and fingers.
6. After the practice period, instruct students who are the "bats" to first put on their bat ears. You may want to help them decide which hand to use for catching the marble. They probably will have greater dexterity using their dominant hand.
7. Instruct the "movers" to gently tip the box lid allowing the marble to roll. After the "bat" catches the marble, rotate jobs until all students have had an opportunity to catch the marble.
8. After the discussion, ask students to write on the front of their bat ears (lines are provided) how if felt to catch the marble using only their sense of hearing.

Discussion

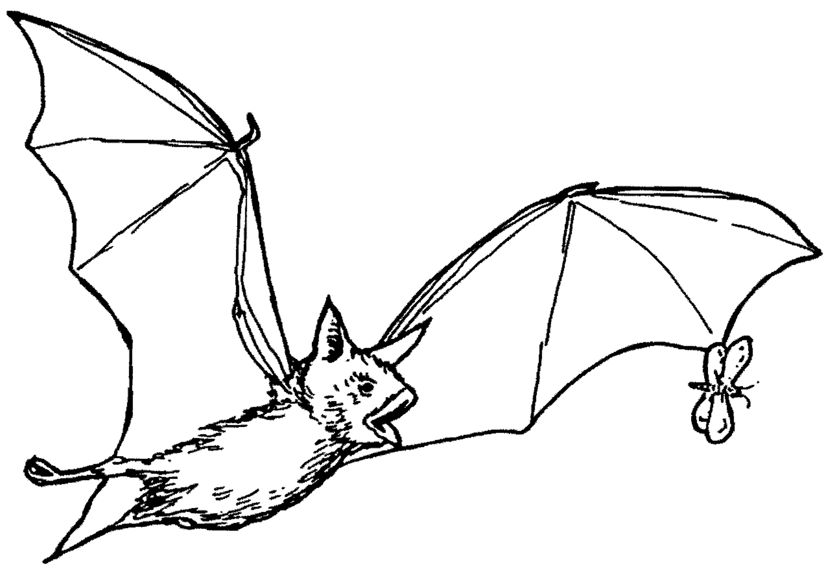
1. Was it as easy for you to catch the marble with your eyes closed as when you could see it? Explain.
2. Did anyone develop a strategy to help you find the marble while you had your eyes closed? What was the strategy?
3. What do you know about the physical characteristics of bats that use echolocation? [they have large ears]
4. How do the large ears help them locate their food?
5. Explain in your own words how bats use echolocation.

Extensions

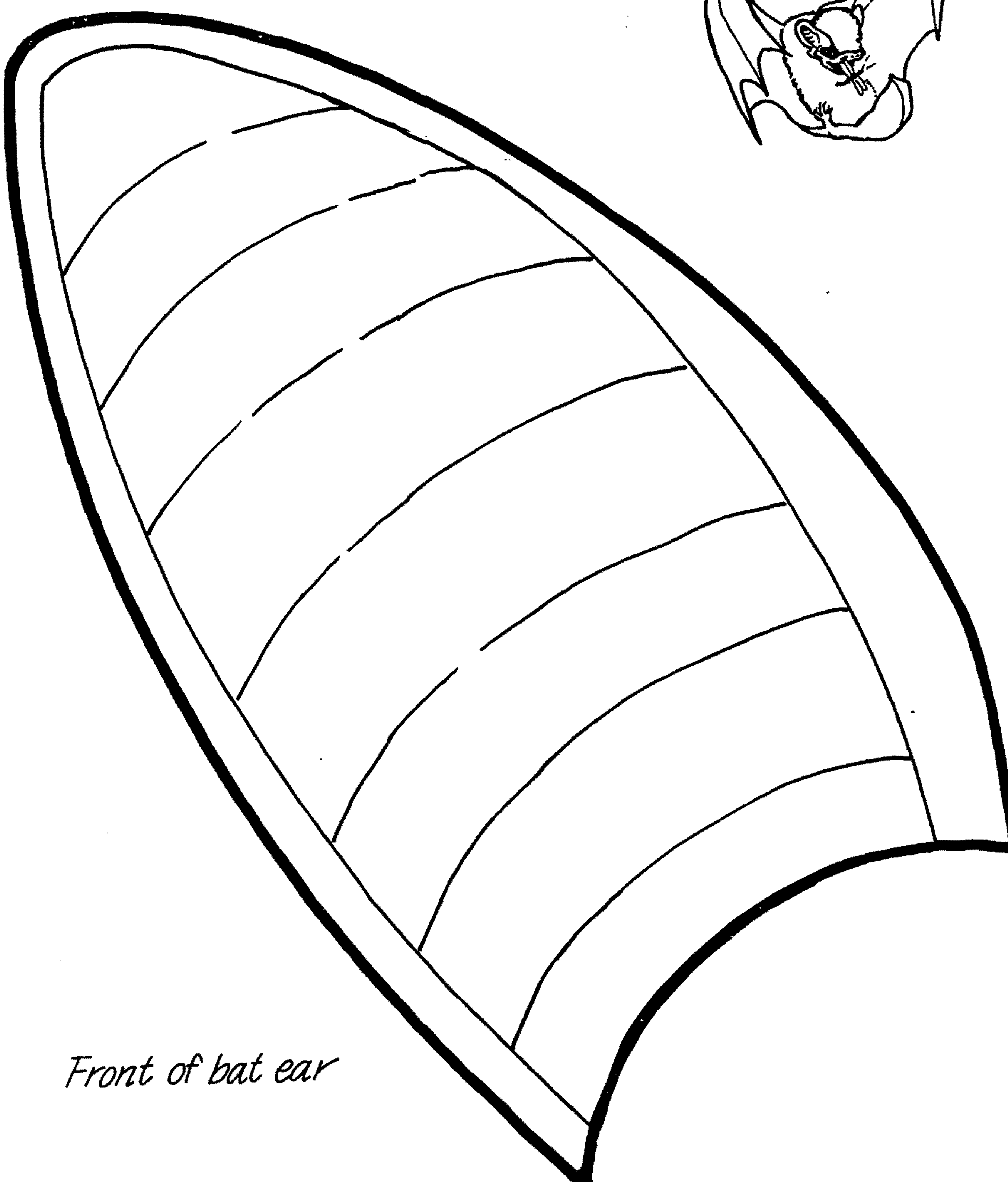
1. Use hard round candy instead of marbles and the "bats" can eat their food.
2. Cover ears, close eyes, and let students attempt to catch the marble.
3. Research and draw ear and head shapes of bats that use echolocation as the means of catching their prey.

Major Conceptual Components

- Bats live in diverse habitats where their unique structures allow them to meet their basic needs.
- Bats have unique structures which allow them to meet their basic needs.
- Bats have unusual facial characteristics such as nose leaves, enormous ears, and intricate faces which allow them to find and eat their food.
- Some bats use sound to help them communicate and navigate.

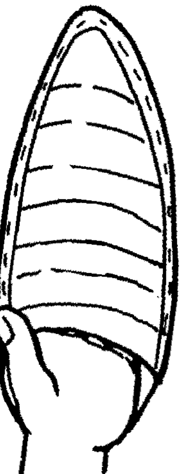


SENSATIONAL EARS



Front of bat ear


Back of bat ear



Wings N' Things

Topic Area
Bat and bird wings

Introductory Statement
The class will build a large bat wing and a large bird wing to fit the students' arms. They will examine the structure and variation between the two types of wings.

Science
Life science
wing anatomy

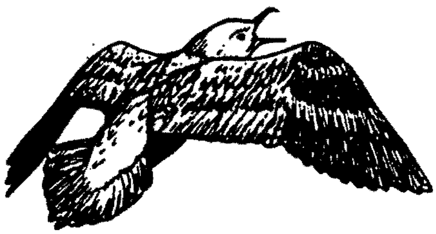
Math/Science Processes
Observing
Comparing and contrasting
Classifying
Communicating

Materials
1 3' x 4' piece of butcher paper for the bird wing
8 3/8" x 3' wooden dowels
3 33-gallon black plastic garbage bags
1 large roll of clear 2" wide clear packing tape or book binding tape
2 transparencies, 1 of the bat wing and 1 of a bird wing
White chalk to trace wing shapes
1 3-inch rubber band.

Key Question
How do bat and bird wings compare?

Background Information
Bats can twist and turn in flight beyond the ability of any other flying creature. Their wings are strong and flexible, allowing them to be aerial acrobats. The skeletal structure of the wing is much like that of a human hand (see *Inside A Bat*). Bats do not have feathers. The skin of the wings is almost transparent and very tough. The wings are driven by powerful chest muscles and in some species, flight is stabilized by a rudder-like tail membrane stretched between the legs. Bats' flight can be in any direction.

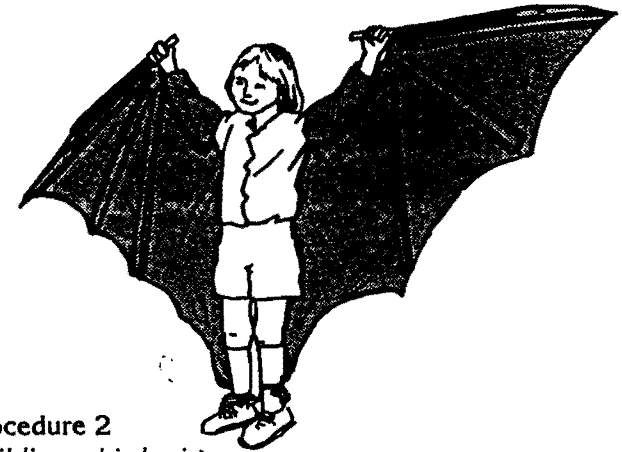
The basic structure of the bird wing is curved like a flattened, upside-down saucer. Air flows past the front edge of the wing. Air pressure below the wing is greater than the pressure above, creating lift. Basically there are four types of bird wings. Birds who soar and ride on hot air currents need long, broad wings for maximum lift. High-speed flight is best achieved by swept-back wings. Long, narrow wings require a great deal of energy to flap, but are perfect for gliding. Fast takeoff comes from short, broad, arched wings. There are many individual variations of birds' wings. Birds' flight only has forward motion and some limited hovering capabilities. (The hummingbird has a unique shoulder which allows a flapping motion in a figure eight.) Birds' feathers are light, flexible, and durable. The feathers create streamlined wings enabling birds to steer with great precision.



Management
1. The activity can be done as a whole class with the teacher making the bat and bird wing. If done by students, it is suggested that it be done in small groups of four with adult supervision.
2. Make a transparency of the bat and a bird wing from the patterns provided.
3. For each bat wing: Cut two large 33 gallon garbage bags along the seam of each side. This will create two pieces of plastic, 2' by 6 1/2'. Tape the plastic pieces together using a long side of each bag. This will create one piece of plastic 4' by 6 1/2'.
4. The third garbage bag will be used to make the casings which are indicated by the long bands on the wing patterns. Trace and cut these casings which later will be taped onto the wings.
5. Determine the location of the overhead projector to achieve the desired 6 1/2' size of the wings and mark it with a piece of masking tape.

Procedure 1
Building a bat wing:
1. Ask the *Key Question*. Inform the class that they will get a chance to build a bat and bird wing to help them answer the question.
2. Move the overhead projector to the masking tape marks and project the shape of the bat wing onto the garbage bag.
3. Using chalk, trace the projected shape of the wing and the casings onto the garbage bag.
4. Cut out the bat wing along this outer line.
5. Tape the long sides of the casings onto the wing. For the narrow casings also tape the bottoms closed so the dowel rods will not fall out.
6. Using 3/8 inch dowels, construct the bone structure of a bat wing on the wing shape (see *Inside a Bat*) by inserting the dowels into the four narrow casings.
7. Have a student slip his or her arm into the arm casing and hold the top, first-finger dowel. Pull the wing up to the side of the students' body. To hold the bot-

tom of the wing, put the rubber band around the student's ankle (same side of the body that the bat wing fits). Tuck the bottom edge of the bat wing into the rubber band.



Procedure 2

Building a bird wing:

1. Select one of the bird wing shapes from the patterns provided.
2. Use the overhead projector to enlarge the bird wing pattern on butcher paper.
3. Tape the casings onto the bird wing pattern. Insert the dowels where indicated in the illustration.
4. When both wings are finished, allow students to try them on.

Discussion

1. What are the characteristics of bats' wings?
2. How does the structure of a bat's wing differ from a bird's wing?
3. What gives bats more flexibility in flight than birds?
4. How did it feel to wear a bat or bird wing?

Extension

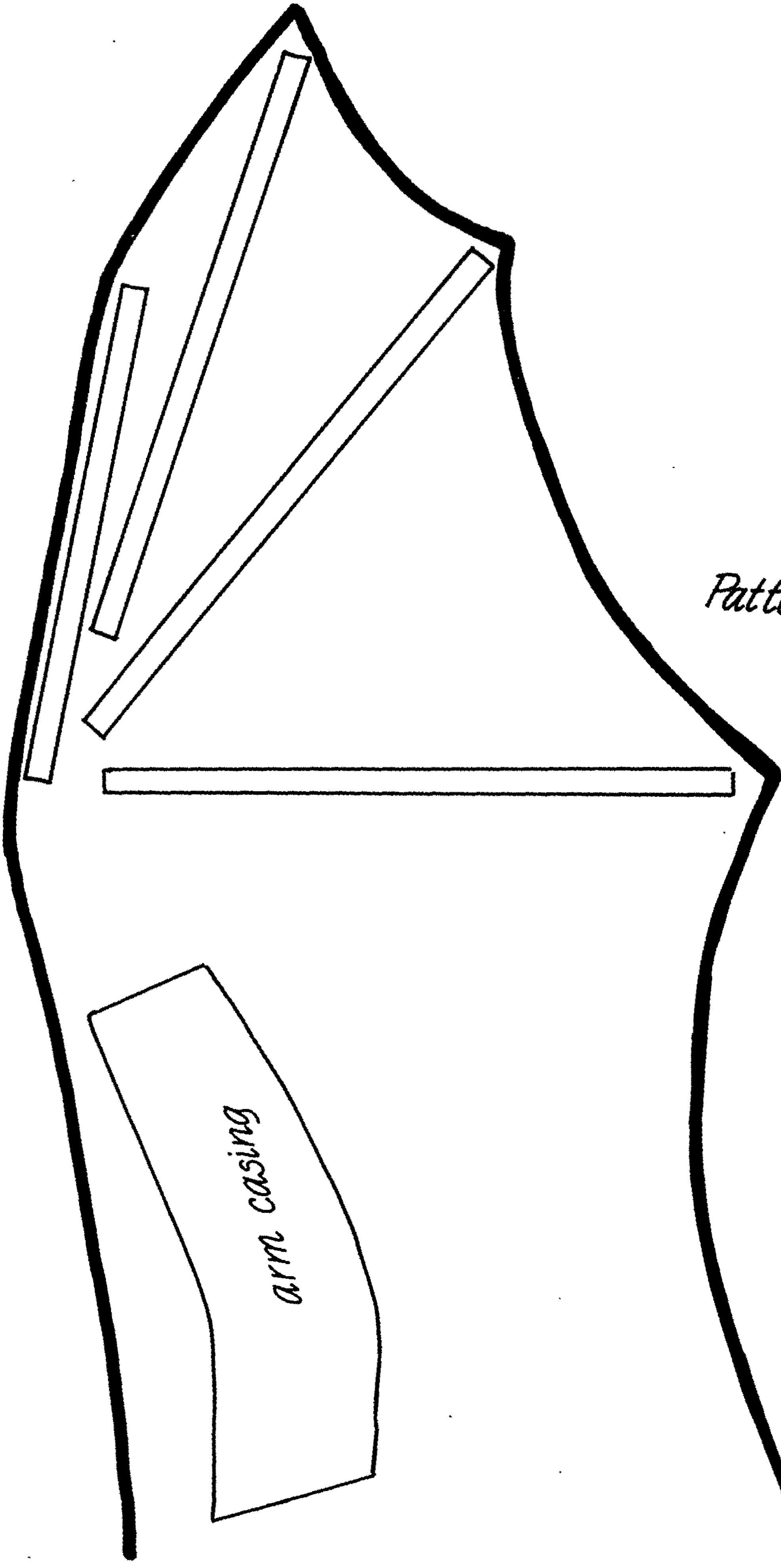
Compare airplane wings to both bat and bird wings.

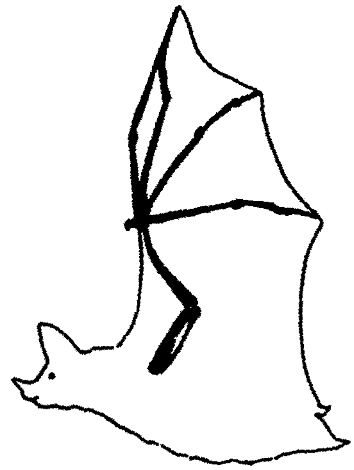
Curriculum Correlations

1. Read *Wings* by Nick Bantock. (Inter Visual Communications, Inc.)
2. Read *Wing Shop* by Stephen Gammell. Have students design their own wings and describe the type of flight for which their wings are best suited.
3. Read *Stellaluna* by Janell Cannon.

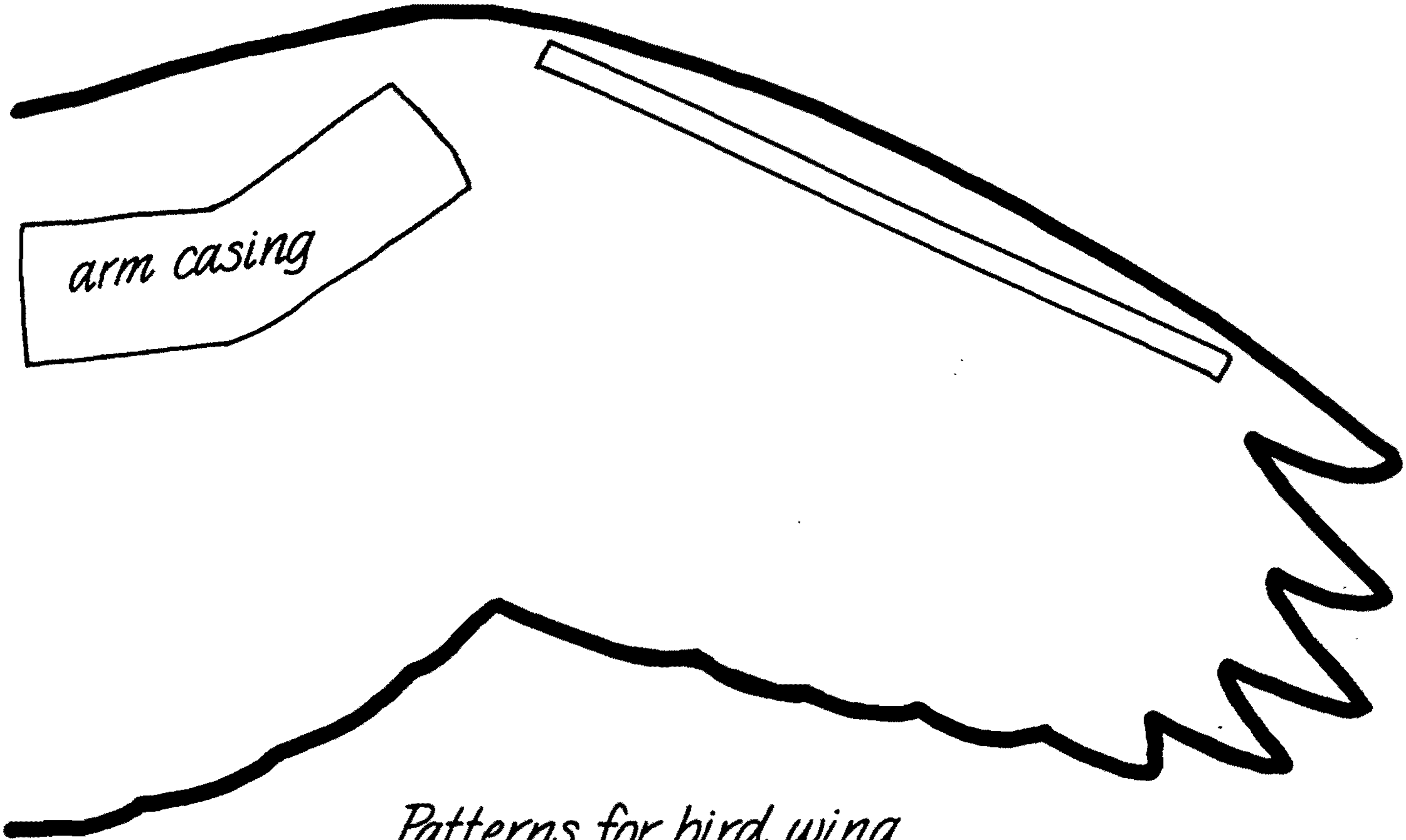
Major Conceptual Components

- Bats live in diverse habitats where their unique structures allow them to meet their basic needs.
- Bats have unique structures which allow them to meet their basic needs.
- A bat's wing allows flexible and effective flight.
- A bat's wing can be compared to the human hand and arm.
- The flights of birds and bats vary due to the structure of their wings.

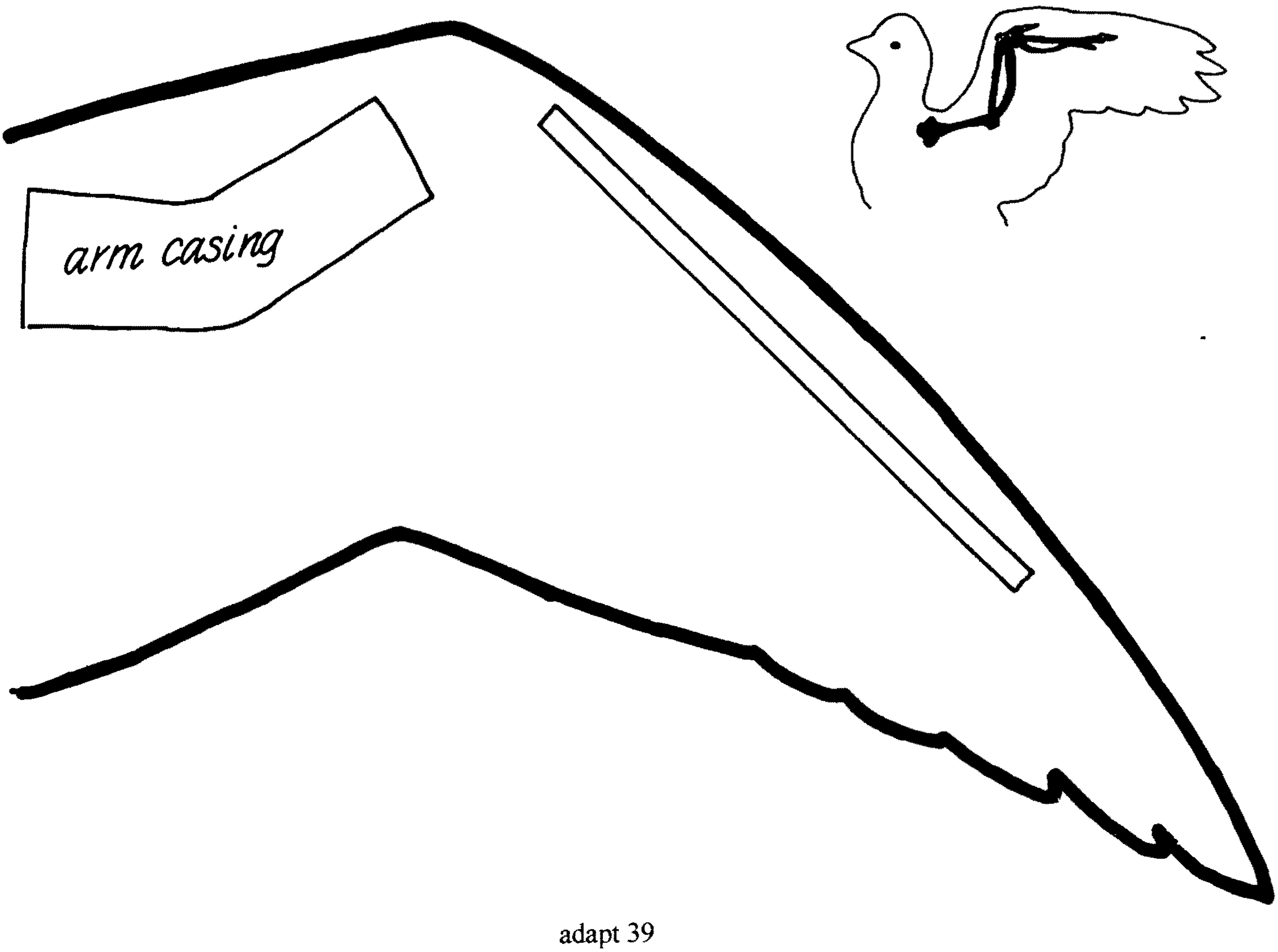




Pattern for bat wing



Patterns for bird wing



ADAPTATION ARTISTRY

Objectives

Students will be able to: 1) identify and describe the advantages of bird adaptations; and 2) evaluate the importance of adaptations to birds.

Method

Students design and create imaginary birds, and write reports including descriptions of the birds' adaptations.

Background

NOTE: See "Thicket Game." Use as an introduction to the concept of "adaptation," followed by "Adaptation Artistry."

Birds have a variety of adaptations—including characteristics of beaks, feet, legs, wings, and coloration. These adaptations have evolved so that the bird is better suited to its environment and lifestyle. A variety of major adaptations are listed below:

Adaptation		Bird	Advantage
Beaks	pouch-like	pelican	can hold fish, a food source
	long, thin	avocet	can probe shallow water and mud for insects, a food source
	pointed	woodpecker	can break and probe bark of trees, for insects, a food source
	curved	hawk	can tear solid tissue, like meat, a food source
	short, stout	finches	can crack seeds and nuts, a food source
	slender, long	hummingbird	can probe flowers for nectar, a food source
Feet	webbed	duck	aids in walking on mud, transportation
	long toes	crane, heron	aids in walking on mud, transportation
	clawed	hawk, eagle	can grasp food when hunting prey
	grasping	chicken	aids in sitting on branches, roosting, protection
Legs	flexor tendons	chicken	aid in perching, grasping
	long, powerful	ostrich	aids running, transportation
	long, slender	heron, crane	aids wading, transportation
	powerful muscles	eagle, hawk	aids lifting, carrying prey, transportation
Wings	large	eagle	aids flying with prey, soaring while hunting
Coloration	bright plumage	male birds	attraction in courtship, mating rituals
		female birds	aids in camouflage while nesting, protection in shelter
	change of plumage with seasons	owl ptarmigan,	provides camouflage protection (brown in summer, white in winter), protection in shelter

The major purpose of this activity is for students to realize that there are advantages for birds in looking how they do, recognizing some of the ways in which birds are physically adapted to their environments.

Materials

drawing, painting, clay sculpture or papier mache' materials; construction paper and glue; pencil and paper

Age: Grades 4—9
Subjects: Science, Art, Language Arts
Skills: analysis, application of concepts, description, discussion, drawing, invention, media construction, observation, problem solving, reporting, synthesis, writing
Duration: one or two 45—minute periods
Group Size: any
Setting: indoors (outdoors optional)
Conceptual Framework Reference: III.D., III.D.1., III.D.2.
Key Vocabulary: adaptation

Procedure

1. Discuss with the students the various adaptations given in the background section of this activity, listing the charts on a chalkboard for reference by the students. Or, brainstorm a list of bird characteristics, name the birds with such characteristics, and describe the advantage of the adaptation represented by the characteristic.
2. Tell the students they will each have a chance to design their own original bird—one well adapted to its habitat. Each student should decide:

- where the bird will live
- what it will eat
- its type of mobility
- its sex

3. Based on these choices, the students will decide the adaptations that are necessary for their bird, and write them down before proceeding further.
4. Using their list of adaptations, each student will create his or her own original bird; for example, by drawing or sculpting it.
5. In conjunction with each drawing or sculpture, each student should write a short report which includes the name of the bird and its food sources, habitat, and lifestyle. Students should also include their lists of adaptations, the reasons for the adaptations, and the advantages provided by the adaptations.
6. Completed projects may either be submitted to the teacher, presented to the class, or displayed in the classroom.
7. Optional: Go outside and identify adaptations on real birds!

Extensions

1. Make mobiles of the completed birds.
2. Prepare a slide presentation on an overhead projector showing different types of bird adaptations.
3. The teacher could give the students examples of bird adaptations on the overhead projector or a ditto sheet and the student could explain the reasons for these adaptations.
4. Collect pictures of birds to develop a bulletin board showing some of the adaptations discussed. Look for pictures showing bird parts compatible with the "invented" birds. Display the invented birds. Use the bulletin board during parent conferences.

Evaluation

Name two bird adaptations for each of the following body parts, listing their advantages: beaks, feet, legs, wings, color.

Herptiles

Objectives:

- Compare and contrast reptiles and amphibians
- Classify a herptile as either a reptile or an amphibian, based on the concepts discussed
- Discuss the basic needs of reptiles and amphibians
- Explore and document the process of change, known as metamorphosis, in a frog
- Identify how herptiles have adapted to their environments

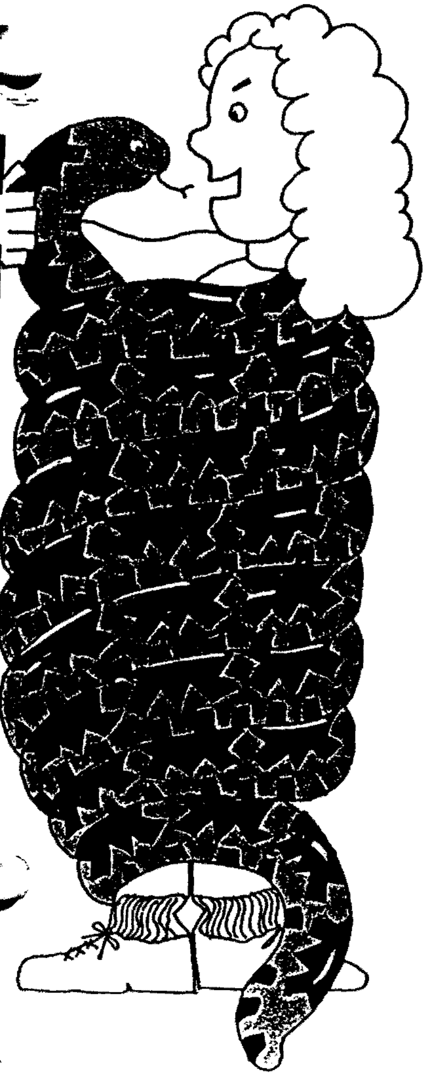
What to Teach	Teaching Suggestion
Teacher background.	- Background information: "Meet the Herps" "Amphibians" and "Reptiles"
Learn the general characteristics of reptiles and amphibians.	- Have students do the activity titled "Hands-on Herps" - Develop a chart with the students comparing reptiles and amphibians. See "Amphibians and Reptiles," from the Massachusetts Audubon Society, as a basis for the chart.
Teacher background.	- Background information: "Amphibian Life Cycle" and "American Toad"
Discuss the change, known as metamorphosis, that amphibians go through in order to "grow up."	- Obtain tadpoles from COSI to have students begin to understand the process by observing it first-hand. - Have students keep a journal and record drawings on what they see occurring. - Salamanders also go through metamorphosis, as diagrammed under "Amphibian Metamorphosis."
Student activity.	- Have students review the process of metamorphosis by doing the activity titled "Metamorphosis Magic."

What to Teach	Teaching Suggestion
Discuss herptile adaptations to their Environments.	- Have the students do the activity titled "Built to Survive." - Expand on the activity and discussion by asking the students how turtles and toads have adapted to their environments.
Turtle adaptations.	1. Turtles have remained virtually unchanged in form since they appeared some 250 million years ago. 2. Turtles have hard, outer shells that enable them to be protected from predators. Most turtles can draw their head and legs up into the shell and close it. 3. Most have sharp claws on their toes, which allow them to burrow into the ground to hide or to build nests for their eggs. 4. Some turtles have webbing between their toes to aid in swimming. 5. Most turtles bask in the sun to warm up their body temperature and to help prevent algae and parasites from attaching to their shells and bodies.
Toad adaptations.	1. Toads (and frogs) can leap great distances away from predators or towards food. Once they reach their prey, toads will quietly stalk it. 2. A toad's tongue is attached to the front of it's mouth. It is also sticky, to better catch prey with. 3. Their skin is colored to blend in with the environment. Most toads will also bury themselves in soil to help hide better.

What to Teach	Teaching Suggestion
	4. Many toads (and frogs) have toxic skin secretions, which ward off predators by making them sick or killing them. 5. Toads will inflate their body if caught, making it difficult for a predator, such as a coyote or snake, to swallow it.
Visit to Sharon Woods Metro Park.	**- The naturalist will lead students on a walk to explore the different habitats of amphibians and reptiles. Students will be shown actual herptiles and a discussion and observation of their adaptations will follow.**
Keep and observe a toad and/or turtle.	- American toads and box turtles are easily found in the backyard or purchased at a pet store. Both make wonderful pets and will provide students with a first-hand look at their special adaptations and lifestyles.
Discuss how some herptiles regulate and maintain their body temperatures.	- What is warm-blooded versus cold-blooded? - Q: How do we keep our bodies the same temperature? - Q: What happens if we get a fever or we get too cold (hypothermia)? - Q: How do animals, such as herptiles, keep their bodies the right temperature? (by using sun and shade) - Have students do the activity titled "Hot and Cold Herps" to better understand the process of temperature regulation.

MEET THE HERPS

Some can go without a meal for more than a year. Others can live for a century—and not really reach a ripe old age for another couple of decades or so. There's one species with a gestation period of up to 38 months, and another whose 2-inch (5-cm) body contains enough poison to kill hundreds of people. What kinds of animals are these? They're *herps*—the collective name given to reptiles and amphibians.



SORTING IT ALL OUT

The word "herp" comes from the word "herpetology," the branch of zoology that focuses on reptiles and amphibians. (*Herpeton* is the Greek word for "crawling things.") Four major groups—lizards, worm-lizards, and snakes; turtles; crocodilians; and the tuatara—make up the reptiles. And amphibians are represented by three groups: frogs; salamanders; and the obscure, wormlike creatures known as caecilians (see-SIL-ee-ans).

A Classy Bunch: Even though reptiles and amphibians are grouped together for study, they're two very different kinds of animals. They're related in the sense that early reptiles evolved from amphibians—just as birds, and later, mammals, evolved from reptiles. (See "Herps, Past and Present" on page 6 for more about ancient herps.) But reptiles and amphibians are each in a class by themselves—just as, for example, mammals are in their own separate class. (A *class* is a broad, scientific grouping of organisms with similar features.)

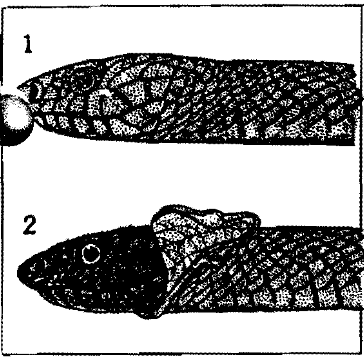
One of the reasons reptiles and amphibians are lumped together under the heading of "herps" is that, at one time, naturalists thought the two kinds of animals were much more closely related than they really are—and the practice of studying them together just persisted through the years.

Reptiles vs Amphibians: Many of the differences between reptiles and amphibians are internal. For example, a reptile's circulatory system and some of its skeletal features are quite different from those of an amphibian. And most reptiles have a better developed lung capacity, resulting in a more efficient respiratory system. But these two groups do have some noticeable external differences too. Most reptiles have claws on their feet and dry skin covered with scales. And most amphibians have clawless feet and moist, scaleless skin. Another difference has to do with eggs and development. Most amphibians lay soft, shell-less eggs in water, and the young usually reach adulthood after passing through a change called *metamorphosis*. Reptiles, on the other hand, usually lay shelled eggs on land. And when their eggs hatch, the young look like miniature adults. As a rule, reptiles also lay fewer eggs than amphibians do. (For more about the characteristics of each of these groups, see pages 19-22 and 36-39.)

WHAT MAKES A HERP A HERP?

Even though reptiles and amphibians are different from each other in many ways, they do have certain important characteristics in common. Here's a look at a few of these characteristics:

External Energy: All reptiles and amphibians are *ectothermic*, or cold-blooded. This means that unlike *endothermic*, or warm-blooded animals (i.e., birds and mammals), herps can't generate enough body heat to maintain a constant temperature. Instead, reptiles and amphibians must depend on an external energy



snake starting to shed its skin

source to provide their bodies with the heat energy they need to function efficiently. To warm up so they can be active, many herps bask in the sun or sit in warm water. And not surprisingly, most herps are sluggish or inactive on cold d
Endothermic animals, on the other hand, generate enough body heat to stay relatively active even when the temperature around them is low. They don't need to rely on external sources to keep their body temperatures up to a "workable" level.

Being ectothermic does have its advantages, though. For example, herps don't need to provide their bodies with the quantity of "fuel" required to maintain a constant temperature. So they don't need to eat as much as birds and mammals do and they can go without food for longer periods of time. And many can live in places that don't have enough food resources to support birds and mammals. (*Note:* Many people prefer to use endothermic and ectothermic, rather than warm-blooded and cold-blooded, to describe how animals regulate and maintain their body temperatures. That's because the terms "cold-blooded" and "warm-blooded" can be misleading if they're not explained. For example, cold-blooded animals don't actually have cold blood.)

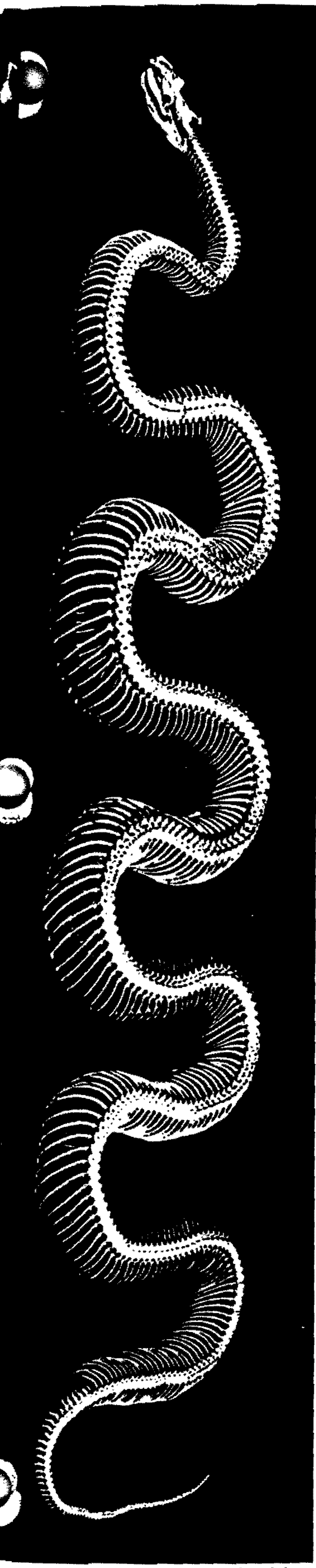
Growing Out of Their Skin: If you spend much time hiking in natural areas, you've probably come across the dry, thin, outermost layer of skin that a snake left behind when it shed. Most other herps also shed their skin from time to time—usually several times a year, depending on how quickly the animal grows. You'd have a tough time finding other herps' skin, though. That's because many herps eat their shed skins, which are a good source of protein.

Herps of a Different Color: Another feature of herps' skin is its ability to change color. Pigment-containing skin cells called *chromatophores* are responsible for color change, and they're usually triggered into action by the temperature, humidity, and/or amount of light in a herp's surroundings. For example, c
temperatures usually cause chromatophore pigments to spread out, and the reptile or amphibian becomes a darker shade of its existing color. Warm temperatures usually have the opposite effect: They cause chromatophore pigments to contract, which causes a herp's color to become lighter. (A few herps can become a different color altogether. For example, some chameleons can change from green to brown, and vice versa.)

A herp's "emotional state"—i.e., fear, nervousness, and so on—can also cause chromatophores to expand or contract. And in some cases so can the color of a herp's surroundings. Chameleons, for example, can become almost invisible by matching the color of the vegetation around them. This ability isn't a conscious effort on the part of the lizard. It's just an automatic response to conditions in the animal's environment.

How Herps Smell: Have you ever wondered why certain snakes and lizards flick their tongues in and out? They're smelling the environment. As a herp's tongue flicks out, it collects molecules from the air and ground and deposits some of them in the paired sensory pockets of the *Jacobson's organ* at the back of the mouth. The Jacobson's organ analyzes the molecules and sends messages to the herp's brain.

Most herps have a Jacobson's organ, though it's not always well developed. And not all of the herps with a Jacobson's organ collect the molecules on their tongues. Some salamanders, for example, collect them through their nostrils. But regardless of how the information is gathered, a Jacobson's organ is helpful to herps in a lot of ways. Among other things, it's useful in tracking down prey, finding a mate, and avoiding predators and toxic substances.



python skeleton
Courtesy of the American Museum of Natural History

A HISTORY OF HERPS

Scientists have traced the history of herps back about 360 million years—to the swampy forests of the Devonian Period. It was during this time that amphibians became the first vertebrates to colonize the land—a major step in the evolution of vertebrate life.

Lobe-fins Lead the Way: The direct ancestors of the amphibians were probably a group of fish known as the lobe-fins. Lobe-fins had several characteristics that other fish didn't have—including lungs (in addition to gills) and fins on their abdomen that were supported by bone. (Other fish had fins supported by "weaker" cartilage.) Scientists think these characteristics facilitated the gradual move of vertebrates onto land. The fish could use their lungs to breathe air and use their fins to support their weight in shallow water. Some scientists think that lobe-fins might have even been able to pull themselves across the land in search of deeper water.

Land of Opportunity: Evolution favored the amphibians' development for several reasons. At the time, there wasn't much competition on land, since certain insects and other invertebrates were the only animals that had managed to colonize it. And unlike the teeming waters, land habitats were virtually free from predators. Plus, the land-dwelling insects, spiders, and other invertebrates were an untapped source of food.

With such a rich world available to them, the new amphibians "took over." They spread out into the swampy forests, adapting to the conditions of the time. Some of these early amphibians were huge by today's standards—as large as or larger than a good-sized crocodile. (By contrast, most modern amphibians are less than six inches [15 cm] long.)

The Water Connection: For 100 million years or more, amphibians were the dominant animals on land. But even though they didn't have much competition, they did depend on specific habitat conditions in order to survive. They required a wet (or at least moist) environment for laying their eggs. And most needed to stay moist themselves in order to "breathe," or respire, through their skin, and to prevent dehydration.

Over time, some forms of amphibians evolved that were somewhat less dependent on water than their predecessors. And although scientists haven't been able to find all of the fossil pieces to the puzzle, they believe that these particular amphibians were the ancestors of the reptiles. The reptiles evolved over a period of many millions of years—and by at least 260 million years ago, they had definitely "arrived."

The Reptiles' Reign: This new group of animals was far less dependent on water than amphibians. For example, their shelled eggs were naturally protected from drying out—so they didn't have to be laid in water. And reptile skin didn't need to stay moist, since respiration wasn't one of its functions and scales kept the animals from becoming dehydrated.

Armed with these and other advantages, reptiles populated habitats that previously had been unavailable to land vertebrates. One group of reptiles, the dinosaurs, eventually became the "rulers" of the Earth. And they held on to that title for more than 160 million years, until some mysterious series of events caused their downfall.

AMPHIBIANS

Compared with other vertebrates, amphibians tend to be overlooked. Why? Maybe it's because they aren't "warm and fuzzy" like mammals. Or maybe it's because they don't evoke the fascination, fear, and respect in people that reptiles often inspire. Or it could be because they lack the sporting appeal of fish or the enjoyment that comes from watching birds. But whatever the reason, they deserve a closer look.

In many ways amphibians are unique, with adaptations that are either rare or nonexistent elsewhere in the animal kingdom. And the diversity amphibians show in certain aspects of their lives, such as whether or not they care for their young and how they go about doing it, surpasses that of most other classes of animals. (See "Far-Out Frogs" on page 29 for some incredible examples of how amphibians care for their young.) Obviously, there's more to the amphibians than their humble image reveals.

WHO ARE THE AMPHIBIANS?

As we mentioned in "Sorting It All Out" on page 3, the amphibians include three groups: the salamanders, the frogs, and the caecilians (see-SIL-ee-ans). A combination of factors, such as cold-bloodedness, moist skin, and eggs without shells, characterizes these three kinds of animals as amphibians. Here's a more in-depth look at each group:

SALAMANDER SECRETS

Lizard Look-Alikes: Some people mistake salamanders for the reptiles called lizards. At first glance, some salamanders do look quite a bit like small lizards. But their physiologies, behaviors, and certain other characteristics are very unlizardlike. For example, salamanders don't have claws on their toes or scaly skin, as lizards do. And most live in temperate climates, either in cool, moist areas on land or in ponds, streams, or other bodies of water. Many lizards, on the other hand, live in drier habitats, and their distribution includes more tropical areas.

Hidden Abundance: Salamanders are usually small and quiet, and they pretty much keep to themselves. Because of this, the high number of these amphibians in certain areas can be surprising. In some forests, for example, scientists estimate that there are far more salamanders than mammals and birds put together. But unless you actively searched for them, you'd never know so many of them were there.

Nighttime Prowlers: One reason salamanders tend to be inconspicuous is that they usually stay put during the day. They rest under layers of dead leaves and other vegetation or under rocks in creeks to avoid the drying heat of the sun. But at night many salamanders come out of their hiding places. They hunt in the darkness, using their keen sense of smell and vision to help them find worms, insects, crustaceans, and other prey.

AMPHIBIANS THAT BURROW—THE CAECILIANS

"Worms" with Backbones: Not many people have heard of caecilians. These little-known tropical amphibians look, and to some extent act, like earthworms. A few are completely aquatic, but most caecilians spend their time on land, in burrows that they dig with their bullet-shaped heads. *(continued next page)*

Underground Hunters: In their underground tunnels caecilians hunt for termites, earthworms, and other small animals. Some of the larger caecilians, wh[illegible] can grow to five feet (1.5 m) long, also eat larger animals such as lizards. Scientists think that a strong sense of smell helps caecilians find their prey. Their "seismic" sense of hearing may also help out. (Caecilians' ears are probably very sensitive to vibrations in the ground but not to sound waves traveling through air.)
A Link With the Past?: We pointed out in chapter one that amphibians, unlike reptiles, don't have scaly skin—but caecilians are an exception. Many species have bony scales embedded in their skin, although these scales are more like those of fish than those of reptiles. Scientists aren't sure what the function of caecilians' scales are, but many think they may be a carry-over from the animals' "fishy" ancestry.

FINDING OUT ABOUT FROGS AND TOADS

Close Cousins: One of the most commonly asked questions about this group of amphibians is, "What's the difference between a frog and a toad?" Most people use the word "frog" to refer to the members of this group with smooth skin that spend the majority of their time in or near water. And most use the word "toad" to refer to the warty, chubby-looking ones that tend to spend more time away from water. But these aren't scientific groupings. They're just common names. And scientists usually refer to all members of this group as "frogs."
Conspicuous Callers: Accounting for nearly 85% of all amphibians, frogs are the extroverts in the group. Far from being reclusive and secretive, many frogs make their presence known with loud, distinctive calls. The males do most of the calling, often creating resonating chambers for their calls by inflating one or mo[illegible] vocal sacs with air. The most frequently made calls are the males' mating calls during the breeding season. But males and females make several other kinds of calls too. (For more about frog calls, see "Call of the Wild" on page 26.)
Here, There, and Everywhere: At certain times of the year, you can hear frogs calling throughout the night almost anywhere there's standing or slow-moving fresh water. From mountains to rain forests to prairies, just about every type of habitat is home to at least one type of frog. And some, such as certain species of spadefoot toads, even live in deserts.
From Vegetarian to Carnivore: Like salamanders and caecilians, adult frogs are carnivorous. Almost any small animals that move—insects, earthworms, fish, and even an occasional bird, snake, turtle, or mouse—are fair game if a frog can catch them. But unlike other amphibians, most frogs don't start out as meat eaters. Before they undergo metamorphosis, they eat mainly bacteria and algae. (A frog's intestines "shrink" to as little as 15% of their original length as the *tadpole*, or young frog, undergoes metamorphosis. The adult's shorter intestines are adapted to digesting animal food rather than the plant food the frog ate when it was a tadpole.)

CHANGE OF LIFE

A process that changes a plant-eating, aquatic animal with a long gut into a meat-eating, semi-terrestrial animal with a short one deserves special attention. Not all amphibians go through metamorphosis—some, for example, hatch from their eggs as miniature versions of the adults. But these *direct developers*, as they're called, are in the minority.
Encased in Jelly: Although metamorphosis is most striking in the frogs (compare a tadpole to an adult frog), this "change of life" occurs in the same basic sequence in all three groups of amphibians. First, of course, comes the egg. Most egg-laying

bullfrog Leonard Lee Rue III

amphibians lay their eggs in water—in shallow ponds, marshes, swamps, ditches, or even (depending on the species) in tiny puddles of water that have collected among the leaves at the base of certain plants.

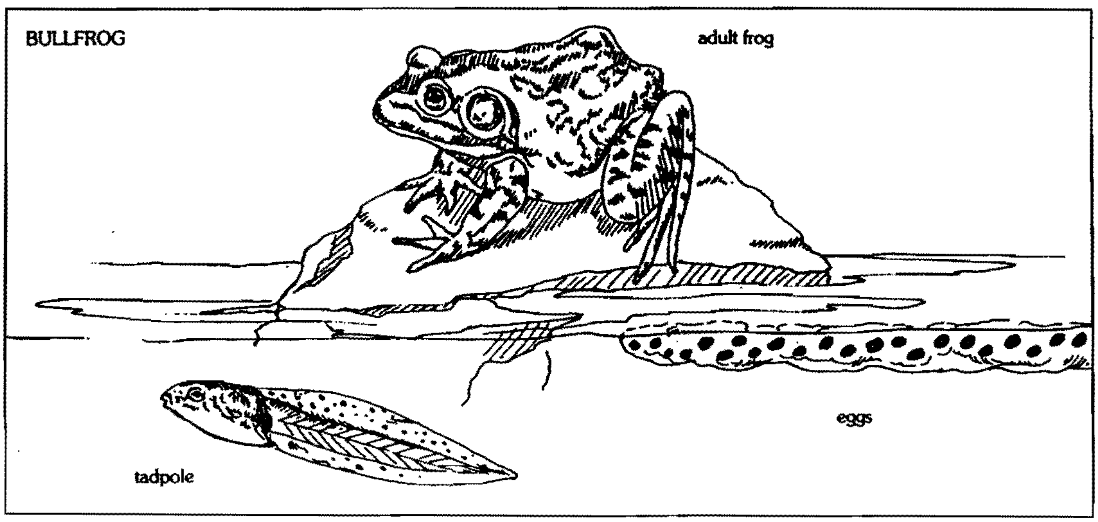
An egg is rarely "alone" in its watery world: Most amphibians lay dozens or even thousands of eggs at a time. The eggs usually form either big clumps, as with some salamanders and frogs, or long strands, as with other frogs. (Not all amphibians lay eggs, though. For example, a few salamanders and frogs, as well as many caecilians, give birth to live young.)

Each amphibian egg is covered with a clear or translucent "jelly" that helps protect the developing embryo. The embryo itself is a small cluster of cells in the middle of the jelly. It develops over a period of as little as one to two days or as long as several months, then hatches into the next phase of its life.

Life as a Larva: Once it hatches, a young amphibian, or *larva,* spends most of its time feeding and growing. The rate at which it grows and the length of time it spends as a larva depends on the species as well as on conditions such as food availability and the temperature of the water. (The less food there is and the cooler the water temperature, the longer the period before metamorphosis takes place.) Some amphibians, such as bullfrogs, may not go through metamorphosis for a year or more after hatching—even with plenty of food and optimal water temperatures. But others are quick-change artists. Some spadefoot toads, for example, can metamorphose into an adult about two weeks after hatching.

On the other hand, some salamanders never go completely through metamorphosis. They eventually become sexually mature, but they remain in water all their lives and never lose their gills or other larval features.

(continued next page)



Growing and Changing: Many of the changes an amphibian goes through during metamorphosis involve major alterations in physiology, anatomy, and behavior. For example, we've already discussed one of the major changes a tadpole experiences—i.e., the shortening of its intestines. Another change, which takes place not only in tadpoles but also in most salamander and caecilian larvae, is the replacement of gills with lungs.

In some young amphibians, such as tadpoles, a major revamping of the body shape and form occurs along with changes inside the body. For example, back legs and front legs grow, the tail shrinks and finally disappears as it's absorbed into the body, and the mouth expands from a small hole to a large opening capable of swallowing large insects and other food. These major changes reflect the fact that life on land as an adult requires different adaptations from life in the water as a larva.

STAYING ALIVE

"Beings with a double life." That's the definition of *amphibios,* the Greek word from which the word *amphibian* developed. It's a fitting definition for a group that has taken to the land and yet remains tied to the water.

The "double life" that amphibians lead has resulted in a lot of interesting adaptations. Some of these adaptations reflect the demands of life on land, others reflect the demands of an aquatic existence, and still others are useful in both kinds of habitats.

Slime and Poison: Some people mistakenly describe snakes and other reptiles as slimy—but it's the amphibians that can claim credit for this trait. The slime, or *mucus,* comes from glands in an amphibian's skin, and its function is to keep the skin moist—an important job that facilitates respiration. In aquatic species, mucus also helps to control the amount of water that passes into the skin.

Besides mucous glands, amphibians also have poison glands in their skin. In most cases the poison these glands produce is no more than a foul-tasting irritant that discourages predators. But some species also produce powerful toxins that can easily kill enemies—including people.

Colors That Communicate: The ability to produce a strong poison often goes hand in hand with another characteristic: bright colors that warn a would-be predator to stay away. (Many predators learn to avoid brightly colored amphibians after grabbing a poisonous one in their mouth and spitting it out.) Using bright colors to advertise toxicity isn't restricted to the amphibians—many insects, fish, reptiles, and other animals use the same strategy—but some of the most striking examples are found among the frogs and salamanders. The tropical rain forests of Central and South America, for example, are home to dozens of species of dart-poison frogs, most of which are splashed with nearly incandescent shades of red, yellow, blue, and/or other colors. And certain non-poisonous frogs take advantage of their poisonous peers by mimicking their colors and patterns.

Colors That Camouflage: Another strategy for staying alive is using color to camouflage. As with most other kinds of animals, a lot of the amphibians blend in with their surroundings. Aquatic frogs are often green like the water plants they live among, for example, and other frogs and terrestrial salamanders are often dark like the leaves of their forest-floor homes. A few amphibians also have leaflike projections on their bodies, helping them blend in even more.

REPTILES

Reptiles are one *amazing* group of animals. There are giant snakes longer than a bus that can swallow crocodiles whole. There are bizarre turtles with fleshy skin flaps that lure fish to their death. There are three-horned lizards with turret-like eye sockets and tongues as long as their bodies. And there are sea turtles, weighing as much as a large horse, that can swim faster than you can run. And that's just the start. In this chapter, we'll take a close-up look at the characteristics of this diverse crew, which includes turtles, lizards, snakes, and crocodiles, and two lesser-known groups—the worm-lizards and the tuatara. And we'll focus on some of the amazing ways they are adapted for survival.

TAKING A LOOK AT TURTLES

There are over 200 species of turtles in the world, living on almost every continent and in most of the world's oceans. Some turtles, such as sea turtles and softshell turtles, spend almost their entire life in oceans, lakes, or rivers. Others, such as bog turtles and wood turtles, are semi-aquatic, spending their time in bogs, swamps, marshes, and other wetland areas. And many turtles, such as tortoises and box turtles, live their entire life on land. (*Note:* The term "turtle" refers to all the reptiles in this group. "Tortoise" and "terrapin" are sometimes used to refer to specific kinds of turtles.)

What Makes a Turtle a Turtle?: The most noticeable feature turtles share is a shell—the tough, armorlike covering that encloses their bodies. The shell varies from species to species, but it always consists of the same three-part structure: the *carapace,* which covers the back; the *plastron,* which covers all or part of the belly; and the *bridge,* which connects the two. Most turtle shells are covered with horny plates; others are protected by tough, leathery skin.

Turtles lay clusters of eggs in soil or sand. And they breathe with lungs, although a few may also get some oxygen through their skin and the lining of the throat.

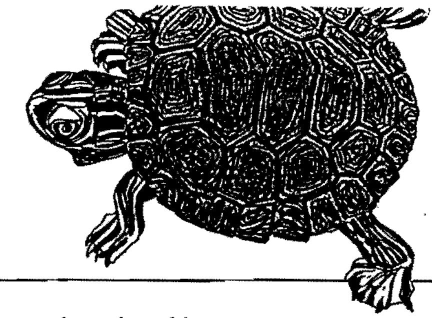
Feeding, Turtle-Style: Like birds, turtles do not have teeth; instead they use their feet and horny beaks to rip, tear, and cut their food. (Most turtles have hard beaks, but a few, such as the matamata, have soft mouthparts.) As a group, turtles feed on a variety of foods, from insects, worms, and fish to fruit, mushrooms, and other plant material.

GETTING TO KNOW LIZARDS, SNAKES, AND WORM-LIZARDS

Together, lizards and snakes make up the largest group of reptiles. (There are roughly 3700 species of lizards and 2400 species of snakes.) Even though they don't look like "cousins," these scaly creatures are closely related. By studying fossil remains and comparing characteristics of living snakes and lizards, scientists have concluded that snakes probably evolved from an ancient line of lizards about 135 million years ago. (Worm-lizards, a small group of burrowing reptiles, are also considered part of the lizard and snake group. Although these rarely seen reptiles have characteristics of both lizards and snakes, they are different enough to make many scientists think they should be classified as a separate group.)

LOTS OF LIZARDS

When you're talking lizards, you're talking variety. Take the way they get around. Some climb trees; some glide from tree to tree; some "swim" through hot



false map turtle

ake-eyed lacertid

desert sands; a few can stand up and run on their hind legs; some can crawl upside down; some burrow into the soil; and some don't have any legs at all and slither to get around. Lizards also vary in color, size, and shape, and in the way they behave. So what makes a lizard a lizard? Here are some general lizard characteristics:

Eyes, Ears, and Legs: Like most vertebrates, many lizards have movable eyelids. And most also have external ear openings on the sides of their head. (Most lizards have good hearing, but they also rely on their sense of sight and smell to know what's going on.) And although there are a few species of legless lizards, most lizards have four legs, with five clawed toes on each foot.

Lizard Chow: Lizards usually feed on anything they can catch and swallow, which, depending on the species, can include other reptiles, insects, spiders, worms, and mammals. But some feed mainly on fruit, flowers, and leaves, and almost all vary their diet with the season.

Lizard Survival: When lizards run into trouble, each species has its own survival strategy. Some lizards nimbly scramble out of sight. Others puff up, act tough, and then run. A few stay and fight. Some "freeze." And as was mentioned in chapter one, some can change colors in a matter of seconds to match their surroundings—a great way to seem to disappear quickly.

Some lizards also use their tails as a special defense decoy. When a lizard is attacked, its tail breaks off at a special fracture joint. Often the tail keeps twitching for a few seconds, distracting the predator while the lizard makes a quick getaway. Lizards that lose their tails can slowly regenerate new ones.

Tail and Tongue Tricks: Tails are also important to lizards for other reasons. They help lizards keep their balance as they walk, swim, or run. And many lizards rely on their tails as storehouses of fat that can be used during cold weather and droughts when food is scarce.

Lizards also have well-developed tongues, and many use them to zap their food, clean their eye coverings, smell, and even scare their enemies. Some chameleons' tongues are incredibly long and can shoot out about as far as the length of their body.

Born a Lizard: Most lizards are egg-layers, usually hiding their eggs in nest cavities they dig in the soil, or under logs or rocks. But in some species, the eggs develop inside the mother's body until the embryos are well developed. The females then give birth to live young.

SIZING UP SNAKES

Snakes are missing body parts that many other animals have. For example, they don't have legs, eyelids, outside ear openings, or bladders. And instead of having a pair of lungs, many have only one. Snakes also look very different from most other animals. They have greatly elongated bodies that can twist and turn in ways that make them look like contortionists.

Moving Like a Snake: Snakes can coil, climb, and slither because they have a very flexible spine made up of 100-400 vertebrae, each of which is attached to a pair of separate, thin ribs. Most snakes move in a series of S-shaped curves, pushing themselves along using plants, rocks, sticks, and other irregularities a shove-off points.

Many snakes can also travel in almost a straight line using the wide, overlapping plates, or *belly scales,* on their undersides. Muscles attached to the ribs pull and lift these scales, creating a series of wavelike motions. As the scales push against rough surfaces on the ground, the snake moves forward. Many thick-bodied snakes, such as pythons, often move in this way.

Most snakes use a combination of these two methods, but some also use an accordion-type movement—especially when climbing trees. And a few desert snakes move using a complicated series of sideways body twists.

Snake Senses: Snakes have a variety of ways to sense their environment. They have fairly good "close-up" eyesight and an excellent sense of smell. Their flicking, forked tongue and a structure in the roof of their mouth called the Jacobson's organ are, in combination, responsible for their incredible ability to "smell" their environment. (For more about the Jacobson's organ, see "How Herps Smell" on page 4.)

For a long time, people thought snakes were deaf. But they can actually hear low-frequency sounds and they can feel vibrations. That's why snakes often sense your presence long before they see you.

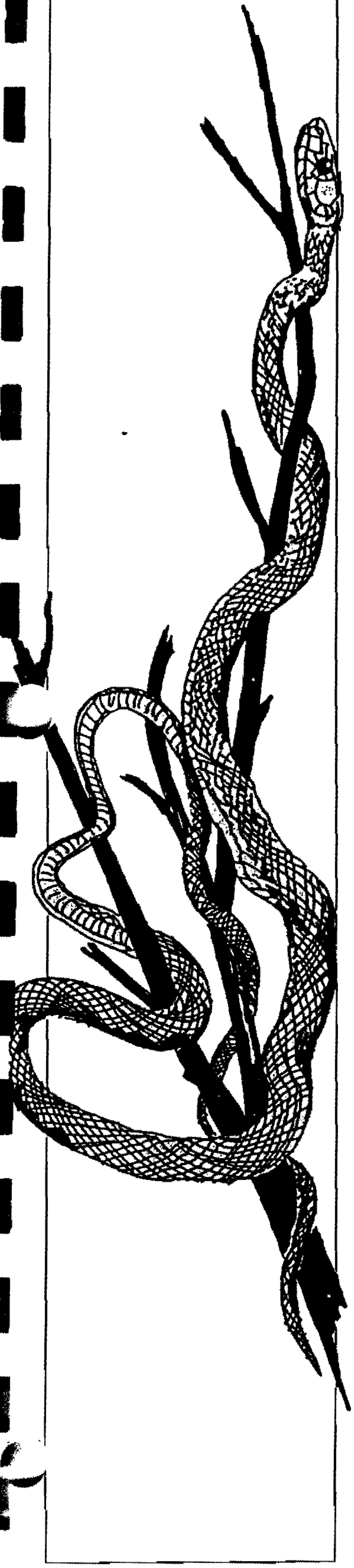
Some snakes also have incredible sensory devices that other reptiles don't have—heat sensors located in pits on the sides of their face or on their lips. These heat sensors can detect slight differences in the amounts of radiant heat energy that animals give off. Snakes process the information to determine both the direction and distance of the objects. These heat sensors allow snakes to successfully hunt mammals, birds, and other prey in complete darkness.

Gulping Their Grub: Snakes always swallow their food whole. They can do this because they have some incredible "mouth machinery." Snakes can move their upper jaw away from their lower jaw and the left side of their lower jaw away from the right side. This expandability, due to extremely elastic muscles and ligaments in the throat and between bones in the jaw, allows snakes to swallow animals that are several times bigger than their head. Most snakes also have rows of sharp, curved teeth on each jawbone that help hold the prey and "walk" it down the throat.

Because they can eat such huge meals at one time and because they are cold-blooded, snakes don't have to eat as often as other animals. If necessary, most snakes can get away with eating just a few times per year. (For more about cold-blooded animals, see "Hot 'n' Cool Herps" on page 10.)

Meat-Eating Strategies: All snakes are meat eaters that feed on a variety of prey, including other snakes, lizards, birds, insects, worms, mammals, amphibians, and fish. Many snakes, such as boas, pythons, and rat snakes, kill their prey by constriction—squeezing so tightly that the victim can't breathe and eventually suffocates. Others, such as garter snakes and water snakes, rely on their jaws and curved teeth to keep hold of their struggling prey. And poisonous snakes, such as rattlesnakes, cottonmouths, and cobras, use venom to subdue their prey. The venom is located in sacs connected to sharp fangs. When some poisonous snakes, such as rattlesnakes, bite their prey, they jab their fangs into the prey's skin or muscle. This forces the venom to flow from the sacs through the fangs and into the animal's body. Other poisonous snakes, such as coral snakes, have shorter fangs, and their venom is injected only after several bites or as they hang on to or chew their prey.

Reproduction, Snake-Style: Most snakes lay eggs, but some give birth to live young, just as some lizards do. And like most reptiles, snakes don't care for their young after hatching. Some snakes, such as pythons, incubate their eggs by coiling their bodies around the eggs until they hatch. And a few snakes, such as the king cobra, use mud, leaves, and other materials to build a nest.



Eastern green mamba

CLOSE-UP ON CROCODILIANS

Crocodiles, alligators, caimans, and gavials—the major types of crocodilians—are all semi-aquatic predators that live in warm areas around the worlc And they all have the distinctive crocodilian look: a large, toothy snout, a compressed, powerful tail, and a tough, leathery hide.

As a group, crocodilians have been around for over 200 million years, having evolved from the same group of reptiles that eventually gave rise to the dinosaurs. The largest crocodilian of all time, *Deinosuchus*, was over 50 feet (15 m) long—a monster compared to crocodilians today.

Adapted to Water: Special adaptations help crocodilians hunt for food, which, depending on their species and age, could include insects, crustaceans, mollusks, fish, amphibians, reptiles, birds, and mammals. Here are just a few of their aquatic feeding tricks:

- eyes and nostrils set high on their head that allow them to see and breathe while the rest of their body is submerged in the water, out of sight
- a third eyelid, called the *nictitating membrane*, that protects their eyes underwater
- nostrils and ears that close when they dive
- a valve at the back of their mouth that closes when they dive, allowing them to catch prey without swallowing water
- a muscular, compressed tail that helps propel them through the water
- webbed feet that help them walk on mud and sand

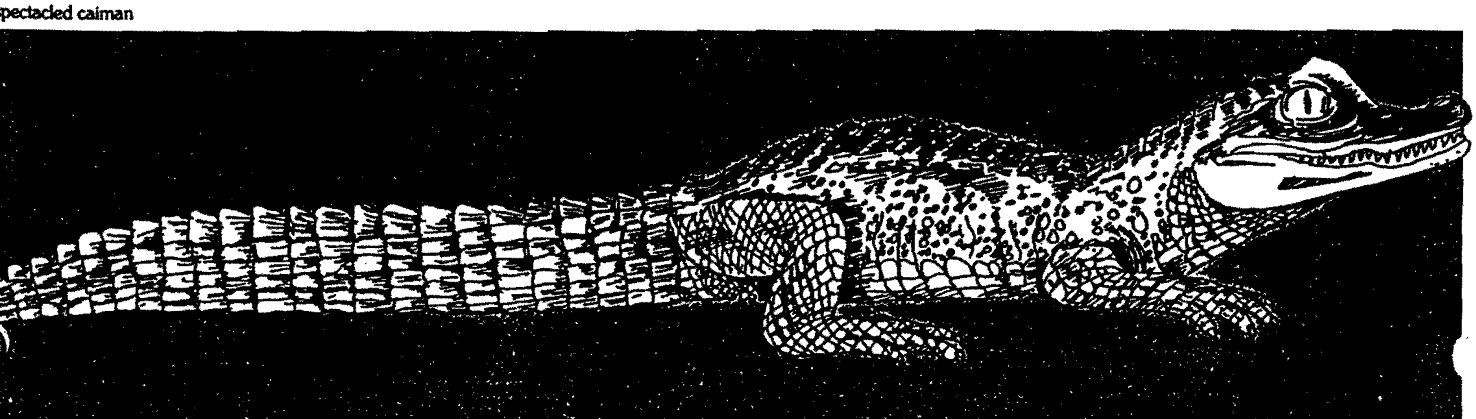
Mounds of Heat: Like most reptiles, crocodilians are egg-layers. Their eggs look something like chicken eggs, although they are not as brittle. Some species dig shallow pits in the sand and bury their eggs. Others hide their eggs in nests of decaying vegetation and mud. Some croc mothers also protect their nests, staying around until the young hatch.

WHAT'S A TUATARA?

Most people have never heard of tuataras—lizardlike reptiles that live on about 30 small islands off the coast of New Zealand. Tuataras are the only survivors of an entire order of reptiles that evolved about 220 million years ago—about the time of the first dinosaurs.

What else is special about the tuataras? For one thing, these nocturnal burrowers have a third "eye" on top of their head, which is connected to their brain and which scientists think is sensitive to light. (Several lizards also have this "eye.") Tuatara eggs also have the longest incubation time of all the reptiles, taking about 15 months to hatch. And many of these reptiles have incredibly long life spans, living more than a century.

pectacled caiman



Hands-On Herps

Learn about the general characteristics of reptiles and amphibians by visiting several "herp stations."

Objectives:
Describe some general characteristics of reptiles and amphibians. Talk about the ways the two groups are alike and different.

Ages:
Primary, Intermediate, and Advanced

Materials:
- ***chalkboard or easel paper***
- ***index cards***
- ***paper***
- ***pencils***
- ***pictures of reptiles and amphibians (optional)***
- ***tables***
- ***for other materials, see the suggestions listed with each demonstration***

Subject:
Science

Here's a hands-on way to help your kids learn about the general characteristics of reptiles and amphibians. Before you begin the activity, set up the "herp stations" described below and on page 8. Also copy each of the instructions shown in color on a separate index card and place the cards at the appropriate stations. (It's best to set up the stations along a few tables to give the kids enough room to work. After setting up, cover or move the tables so that the kids can't see what's on them.)

Note: You can adapt this activity according to the age of your group. For example, if you're working with younger kids, you may want to eliminate stations 5 and 6. We've also included some simpler options at the other stations for younger groups. And if you're working with very young kids, you could "explore" stations 1-4 as a group.

Start the activity by writing the words "reptile" and "amphibian" on a chalkboard or piece of easel paper. Ask the kids to name as many different kinds of reptiles and amphibians as they can think of, and list their suggestions under the proper heading. You can also show them pictures of different herps to give them ideas.

Now tell the kids they'll be learning about the general characteristics of reptiles and amphibians by visiting several stations. Divide the group into pairs and give each pair a piece of paper and a pencil.

Have each pair start at a different station. Give them time to follow the instructions on the index card and write their answer on their paper. Then, on your signal, have them change stations. Continue switching until everyone has visited all the stations.

Afterward gather the group together and go over the answers using the discussion information under "Sorting Out the Stations" on page 9. Based on what the kids learned at the stations, make a list of reptile characteristics and another list of amphibian characteristics. What do the groups have in common? What makes them different? (See pages 3-4 for more about the characteristics of reptiles and amphibians.)

Luise Woelflein

Station #1
SCALES vs SLIME
Materials: A piece of clay with rows of shelled sunflower seeds stuck in it (labeled A). (See page 42 for an illustration of seeds and clay.) A piece of cellophane covered with a thin layer of vegetable oil (labeled B).

Run your finger over material A and then material B. Make a short list of words that describe how each one feels. Which one do you think represents reptile skin and which one represents amphibian skin?
For younger kids: Tell them that material A represents reptile skin and B represents amphibian skin. Then have them feel and describe both materials.

(continued next page)

Station #2
EGGS
Materials: Tapioca sprinkled in a container filled with water (labeled A). A few grapes laid on sand or dirt (labeled B).

Feel the material floating in A and the objects in B. Describe some differences between them. Which ones do you think represent amphibian eggs and which ones represent reptile eggs?
For younger kids: Tell them which objects represent reptile eggs and which represent amphibian eggs, then let them feel each kind. Discuss the differences between the two kinds of eggs.

Station #3
CHANGING COLORS
Materials: A black pipe cleaner taped to a piece of black construction paper (labeled A). A yellow pipe cleaner taped to a piece of black construction paper (labeled B). Tape A and B to a wall about 10 feet (3 m) away from the station.

Which is harder to see, the black pipe cleaner or the yellow pipe cleaner? The colors of some reptiles and amphibians can change. For example, some lizards can change from green to brown. How might this help the lizards survive?
For younger kids: Have them point out the one that is harder to see and discuss their answers.

Station #4
BACKBONES
Materials: Copy of page 49 (optional).

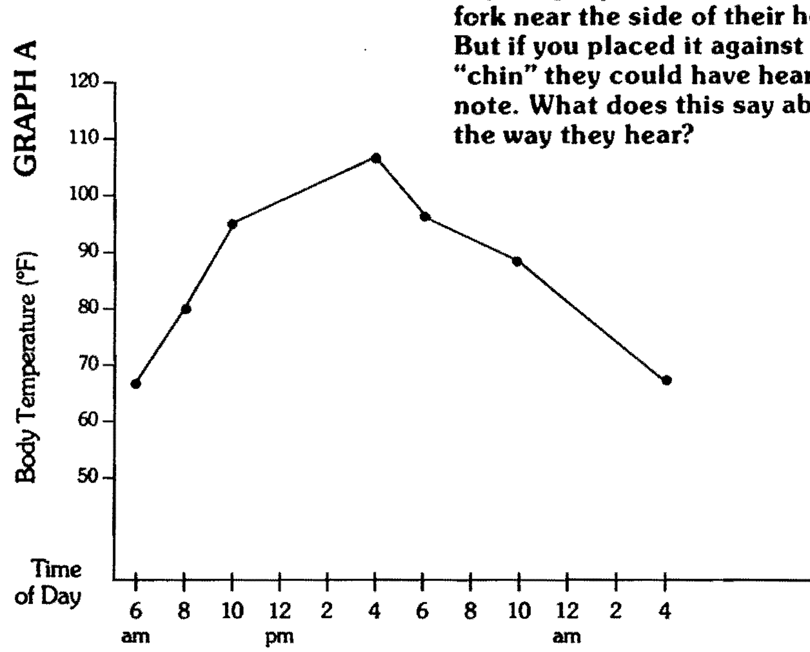
Reach around and feel the middle of your back. What bones do you feel? Which of the groups listed below have similar bones in their back? (You can choose more than one answer.)

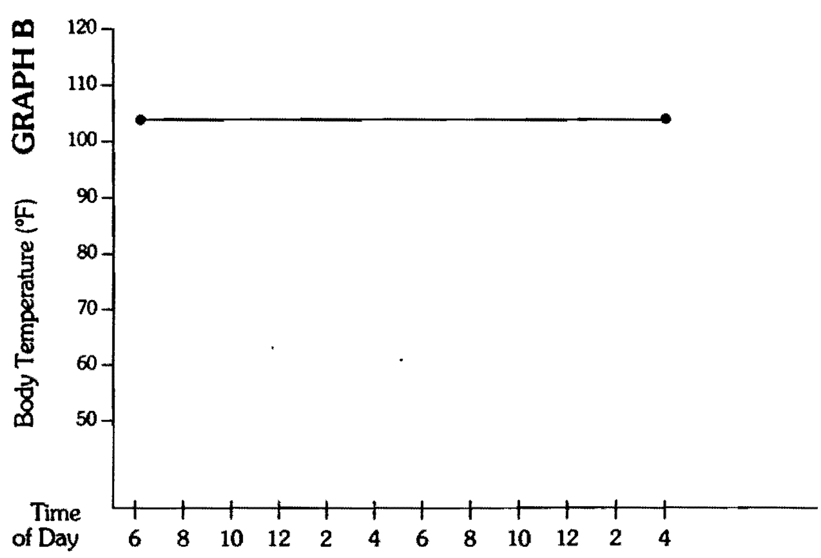
a. **snakes**
b. **insects**
c. **salamanders**
d. **frogs**

For younger kids: Show the kids page 49 and have them guess what it is. (a snake skeleton) Let them feel their backbones, then discuss the fact that all vertebrates, including all reptiles and amphibians, have backbones and internal skeletons.

Station #5
COLD-BLOODED CREATURES
Materials: Copy the two graphs below and label them as shown. Also write down the definitions of *cold-blooded* and *warm-blooded* (see the glossary on page 67).

Graph A shows the body temperature of an animal during one day, and Graph B shows the body temperature of another animal during the same day. What is different about the body temperatures of the two animals? Now read the definitions of cold-blooded and warm-blooded. Can you tell which graph shows the body temperature of a lizard? How did you know?





Station #6
HEAR THOSE VIBRATIONS
Materials: A tuning fork. *Note:* You may want to demonstrate how to listen to the tuning fork before the kids try it. And to avoid scratching the tuning fork, make sure the kids don't tap it on a metal surface.

Hold the tuning fork by the stem and tap it on a wooden chair or table. (Be careful not to touch the two prongs after hitting the fork on the table.) Then hold it next to your ear. Now tap it again and this time place the base of the stem against your chin. (Press it hard!) Describe what happens each time.

Some reptiles and amphibians would not have been able to hear anything if you held the tuning fork near the side of their head. But if you placed it against their "chin" they could have heard the note. What does this say about the way they hear?

Sorting Out The Stations

1. The cellophane covered with oil represents the moist, glandular skin of most amphibians. The clay with seeds in it represents the dry, scaly skin of most reptiles. Point out that not all herps fit these generalizations—for example, many toads have fairly dry, rough skin. And some geckos have smooth skin with inconspicuous scales.
2. The tapioca represents the jellylike feel of amphibian eggs. Explain that amphibian eggs don't have shells, so they don't have much natural protection against drying out. But most amphibian eggs stay moist because they're laid in water or moist areas on land. Then explain that the grapes represent shelled reptile eggs. (Most reptile eggs are firm, like grapes, but not brittle like bird eggs.) Because they have shells, reptile eggs can survive in drier areas than amphibian eggs can.

   Point out that different types of reptiles lay different kinds of eggs. For example, turtle eggs are usually round and have a smooth shell. But many snake eggs are oval and often feel leathery. Also tell the kids that although most herps lay eggs, some do bear live young.
3. The black pipe cleaner (A) should be harder to see. Being able to blend in with their surroundings can help amphibians and reptiles get within striking distance of their prey. And it can help them hide from predators.

   Being able to change color also helps some amphibians and reptiles control their body temperatures. For example, when in direct sunlight, the skin of many herps becomes lighter. Since light-colored surfaces don't absorb as much heat as dark-colored surfaces do, this ability to change color can keep herps from overheating.
4. The kids should feel the vertebrae that form their backbones. All reptiles and amphibians, including snakes, salamanders, and frogs, are vertebrates. Like birds and mammals, herps have backbones and internal skeletons. But invertebrates, such as insects, do not have an internal skeleton. Instead, they have a hard outer covering called an *exoskeleton*.
5. The body temperature of the animal in Graph A changed over time. The body temperature of the animal in Graph B remained the same throughout the day. Graph A represents the body temperature of a cold-blooded animal, such as a lizard, and Graph B represents the body temperature of a warm-blooded animal, such as a bird. Point out that birds and mammals are warm-blooded animals, whereas reptiles, amphibians, and fish are cold-blooded. (For more about warm- and cold-blooded animals, see "External Energy" on page 3.)
6. The kids should have heard the same sound each time. The reason they heard a sound when they held the fork to their chin is that vibrations traveled through the bones in their jaw and skull to the fluid in their inner ear. Here the vibrations were "translated" into nerve impulses and interpreted as "sound" by the brain.

   Most herps, as well as most vertebrates, can detect sound in this way. (In many herps, the jawbone is most sensitive to ground vibrations.) Birds, mammals, and most reptiles and amphibians also have external ears that pick up sound waves in the air. But some herps, such as snakes and salamanders, don't have outer ears, and rely on vibrations to "hear" what's going on.

AMPHIBIANS AND REPTILES

Vertebrate cold-blooded animals (body temperature controlled by surroundings)

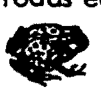
	AMPHIBIANS	REPTILES
Skin	either moist and smooth or dry and warty, no scales	dry, scales
Eggs	usually laid in water	laid on land (some snakes bear living young)
Young	different shape from adults, except salamanders	same shape as adults
Breathe	with gills when young (usually) with lungs when adult (usually)	with lungs at all times
Claws	none	all except snakes
Examples	TOADS, FROGS, SALAMANDERS	SNAKES, TURTLES, CHAMELEONS, LIZARDS, CROCODILES, ALLIGATORS

Most of these animals are harmless; however, the jaws of a large snapping turtle are dangerous. Only two species of poisonous snakes, the copperhead and rattlesnake, are found in Massachusetts, and these are rare. The bites of other snakes are not dangerous unless the wound becomes infected.

Salamanders are often called lizards but actually they are more like frogs with tails. (Lizards have dry and scaly skin and the skin of a salamander is moist and smooth.) They eat mostly insects and other small invertebrates.

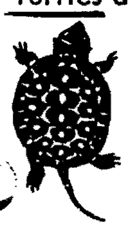
Although adult frogs and salamanders usually have lungs they also breathe through their skin, so must be kept moist at all times. In hibernation they breathe entirely this way.

Frogs eat primarily land or water insects. They have moist smooth skin. Their slipperiness and their ability to jump enable them to escape their enemies. They are much better jumpers than toads. Frogs' eggs are laid singly or in clusters.



Toads eat mainly insects and earthworms. They have a dry warty skin, but people cannot get warts from handling them. Toads lay their eggs in a chain-like formation.

Snakes are very useful animals which should not be killed. The small ones live largely on soft-bodied animals, earthworms, slugs, and some insects. The larger ones eat mice and other small vertebrates, frogs, toads, etc. A snake swallows its prey whole, holding it with teeth which curve back, while the top and bottom jaws move alternately to work the prey down. The hinged jawbones and the elasticity of the skin and stomach allow it to eat animals bigger around than itself. A snake sleeps with its eyes open since it has no moveable eyelids. Its forked tongue is not a stinger but aids the snake in smelling, tasting, and feeling objects.

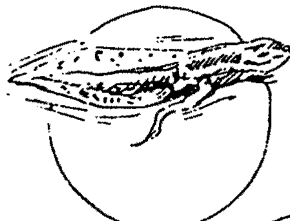


Turtles are among the best protected of animals due to their shell which is like a hard suit of armor. The backbone of turtles is attached to the upper shell and the breastbone to the lower shell. A full-grown turtle has few enemies, but the eggs are often dug up and eaten by skunks or raccoons and the young turtles are often eaten by larger turtles and other water animals. They all lay their leathery-shelled eggs on land, usually digging a hole for them. Some turtles live on land and some in the water.

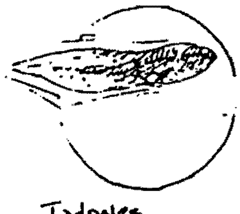
Crocodiles and alligators are not found wild in Massachusetts. One lizard, the Five-lined Skink, may occur in Massachusetts but there is no authentic record. The pet store "chameleon" is really an anole lizard which is common in Florida. A true chameleon is found only in the old world.

AMPHIBIAN LIFE CYCLE

The word amphibian is from the Greek. It means double life and refers to the fact that these animals spend part of their lives in water, and part on land. Most amphibians feed on insects and other invertebrates, although the bullfrog sometimes will eat other frogs.

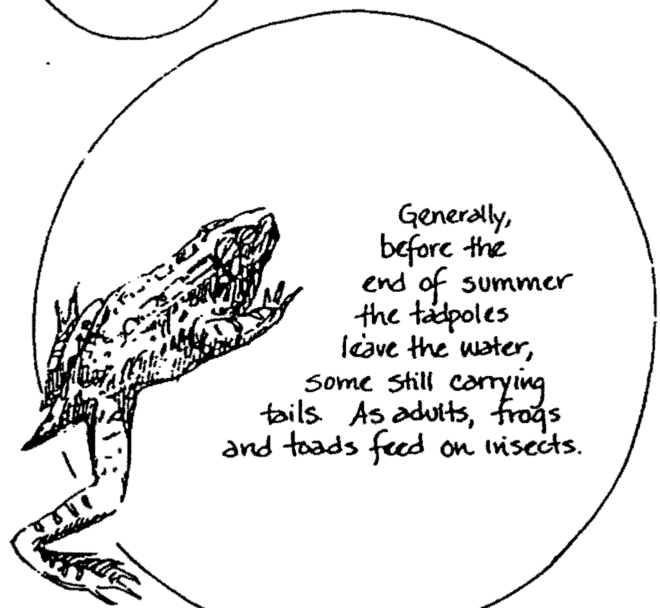


Within a few weeks tadpoles will begin to develop legs.

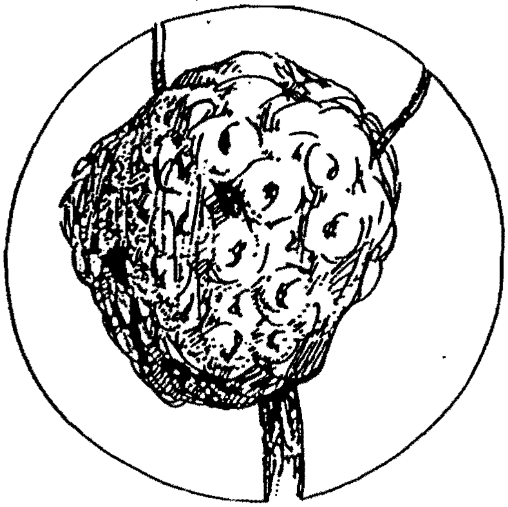


Tadpoles, or larvae, feed on algae.

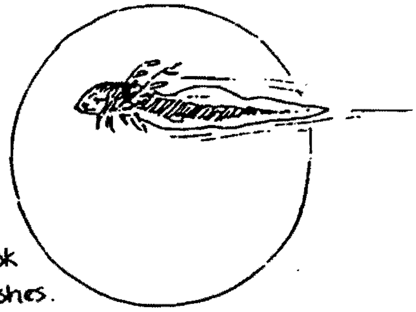
Frog and toad eggs form jelly-like clumps.



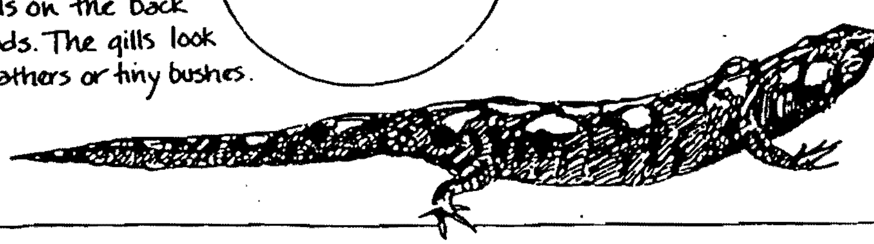
Generally, before the end of summer the tadpoles leave the water, some still carrying tails. As adults, frogs and toads feed on insects.



Salamanders have a similar lifestyle. Eggs are laid early in spring, and larvae feed on algae and other aquatic vegetation. Adult salamanders feed on practically anything that moves, including other salamanders.



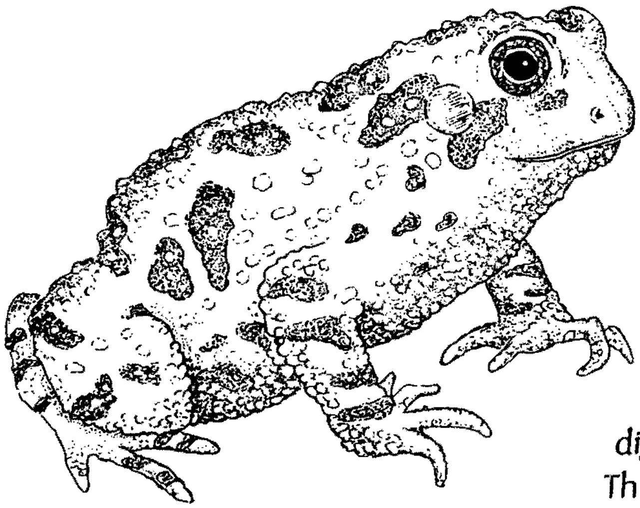
Unlike frogs or toads, salamander larvae have gills on the back of their heads. The gills look a little like feathers or tiny bushes.



For Further Information: A Frog is Born, William White Jr., Sterling Publishing Company.

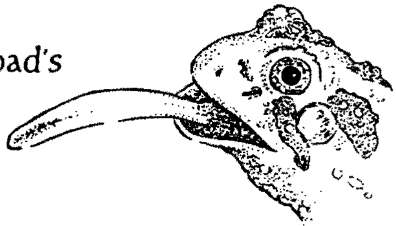
AMERICAN TOAD

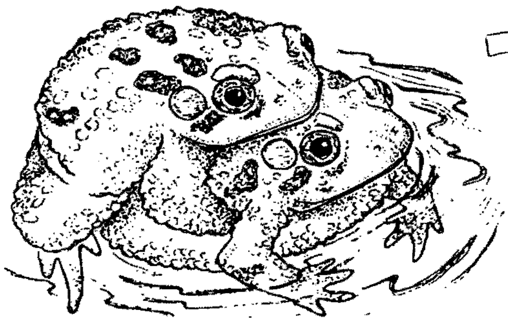
(Bufo americanus)



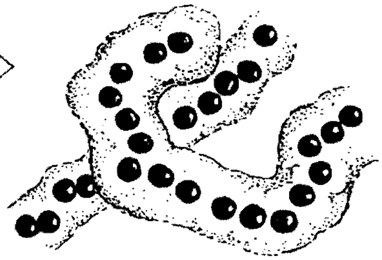
The common toad lives in cool, damp woods and fields. A toad spends more time out of water than a frog. The toad's lungs are more efficient. Toads hop rather than jump. Toads do not cause warts, but if they are frightened their skin glands can ooze a milky juice that burns and irritates their enemy's eyes and mouth, causing the predator to spit out the toad. Toads can also puff themselves up to scare enemies, or dig themselves backward into the dirt to hide. The toad's call is a musical trill up to 30 seconds long.

The long, sticky tongue, attached to the front of the toad's mouth, moves extremely fast to catch insects. Toads eat hundreds of harmful garden insects, usually at night.



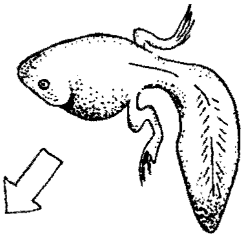


Adults return to the water to mate.



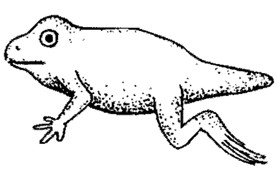
Females lay up to 15,000 eggs in long strings.

The tadpole emerges with external gills and a long tail.

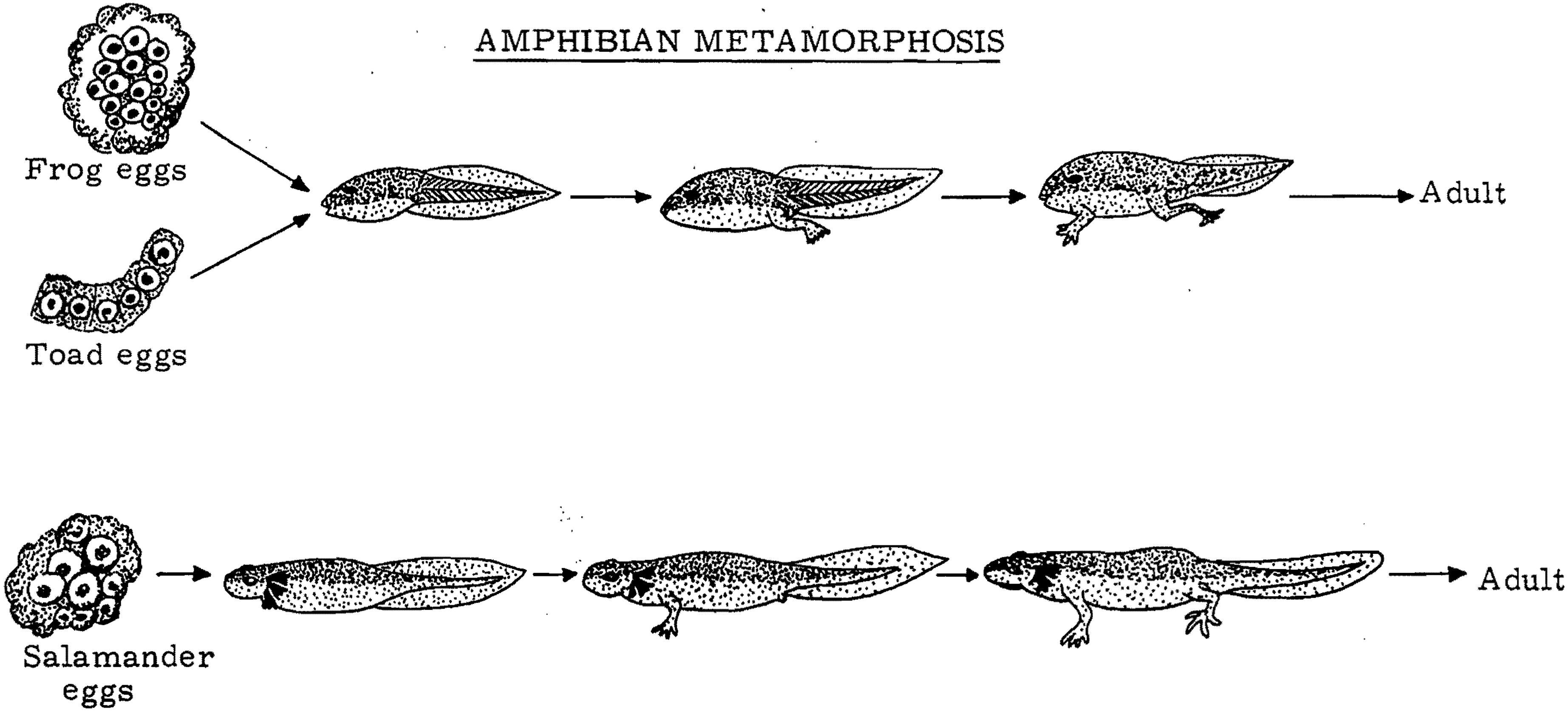


Tadpoles eat water plants by scraping them with filelike teeth.

As the tadpole develops hind legs and then front legs, its tail shrinks. It loses its gills as lungs develop. The nibbling mouth changes to a wide, snapping mouth.



AMPHIBIAN METAMORPHOSIS



BULLFROG BASICS

Eggs—As far as scientists know, bullfrogs lay more eggs at one time than any other frog. (Some females lay over 20,000 eggs!) They lay their eggs in still, shallow water from May to July. (In areas that stay warm most of the year they lay eggs from February to October.) The eggs are laid together in a big clump, or *egg mass*, that floats near the surface of the water. Like other frogs' eggs, bullfrogs' eggs are covered with a jellylike substance that helps protect them. As the eggs are laid, the jelly soaks up water and begins to swell. Sometimes the swollen egg masses are huge—covering as much as five square feet (1.5 m^2).
Tadpoles—Bullfrog tadpoles are olive-green. They feed mostly on algae that they scrape from rocks, large plants, and other surfaces in the water, and they may grow to be over four inches (10 cm) long. In parts of Louisiana and other areas in the South, the tadpoles complete metamorphosis as early as late summer. But in many other areas, they remain tadpoles until the following spring. And in northern areas, such as Maine, they usually don't complete metamorphosis until the spring after that—almost two years after they hatched from their eggs.
Adults—Bullfrogs are the largest frogs in North America. They may be eight inches (20 cm) long and they can weigh over a pound (450 g). They usually live along the banks of ponds, lakes, and slow-moving streams. And they feed on all kinds of animals including insects, other frogs, crayfish, small fish, and even small birds and snakes.

Diagram 1

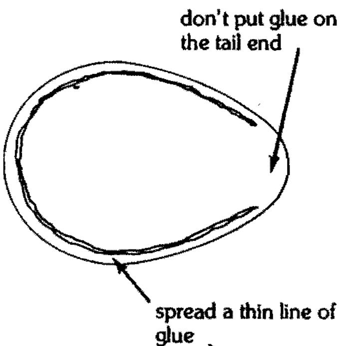


Diagram 2

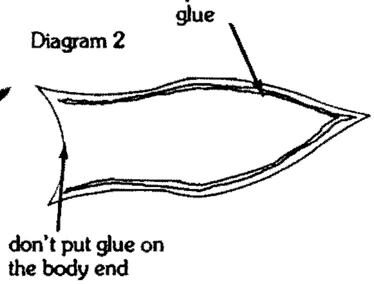
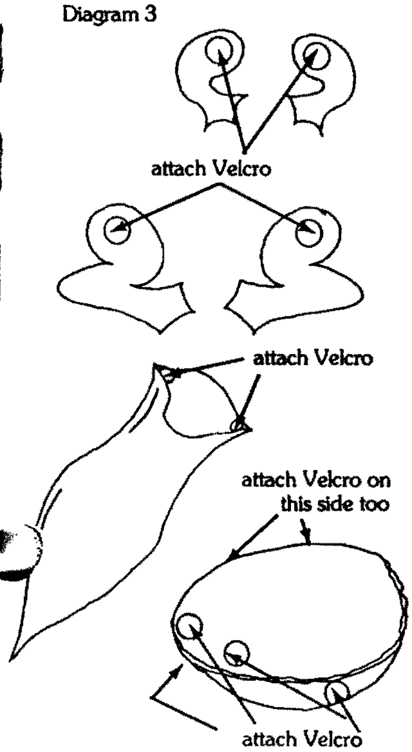


Diagram 3

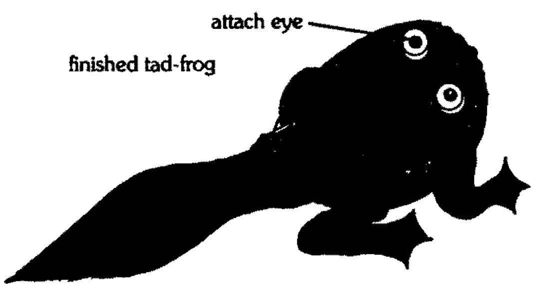


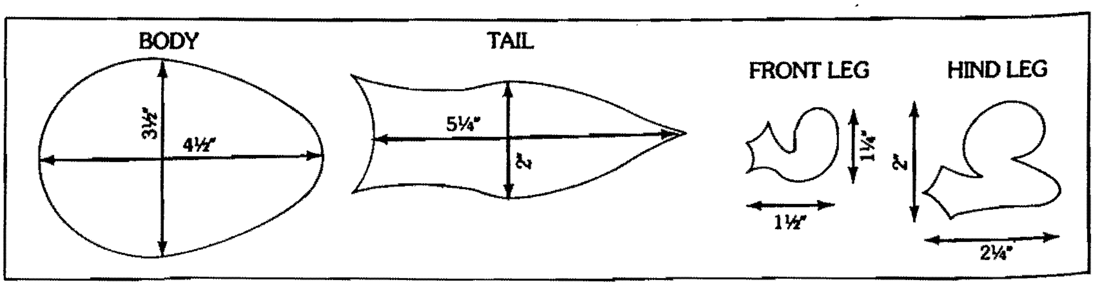
BRANCHING OUT: METAMORPHOSIS MAGIC

As a review, make this tadpole craft and have the kids tell you how to change it into a frog (see step 7). If you're working with older kids you can even let them make their own "tad-frogs."

HOW TO MAKE A TAD-FROG

1. Enlarge and trace two copies of each of the pattern pieces shown below onto a piece of green felt. Cut out all eight pieces.
2. Spread a thin line of glue around the edge of one body piece as shown in diagram 1. (Be sure to keep the tail end free of glue!) Then carefully lay the second body piece on top and let dry. (You may want to put a book or other heavy object on top of the frog's body while it dries.)
3. When the glue has dried, stuff the frog's body with cotton balls or other stuffing. Then glue the open end closed. (Use clothespins to hold the ends together while the glue dries.)
4. Spread a thin line of glue around the edge of one of the tail pieces as shown in diagram 2. (Be sure to keep the body end free of glue!) Then carefully lay the second tail piece on top and let dry.
5. Glue one half of a Velcro fastener to each of the 12 places marked in diagram 3 and let dry. You'll need lots of glue! *Note:* Velcro comes in two parts: One half is covered with hooks and the other half is covered with fuzzy hairs. Be sure you glue the same side of the Velcro to each spot marked on the body and the other halves to the legs and tail.
6. Glue on the eyes and let dry.
7. Attach the tail to make a tadpole. Then turn the tadpole into a frog! (First attach the back legs, then the front legs, and then remove the tail.)





Built to Survive!

Take a close-up look at the adaptations of a frog and a salamander.

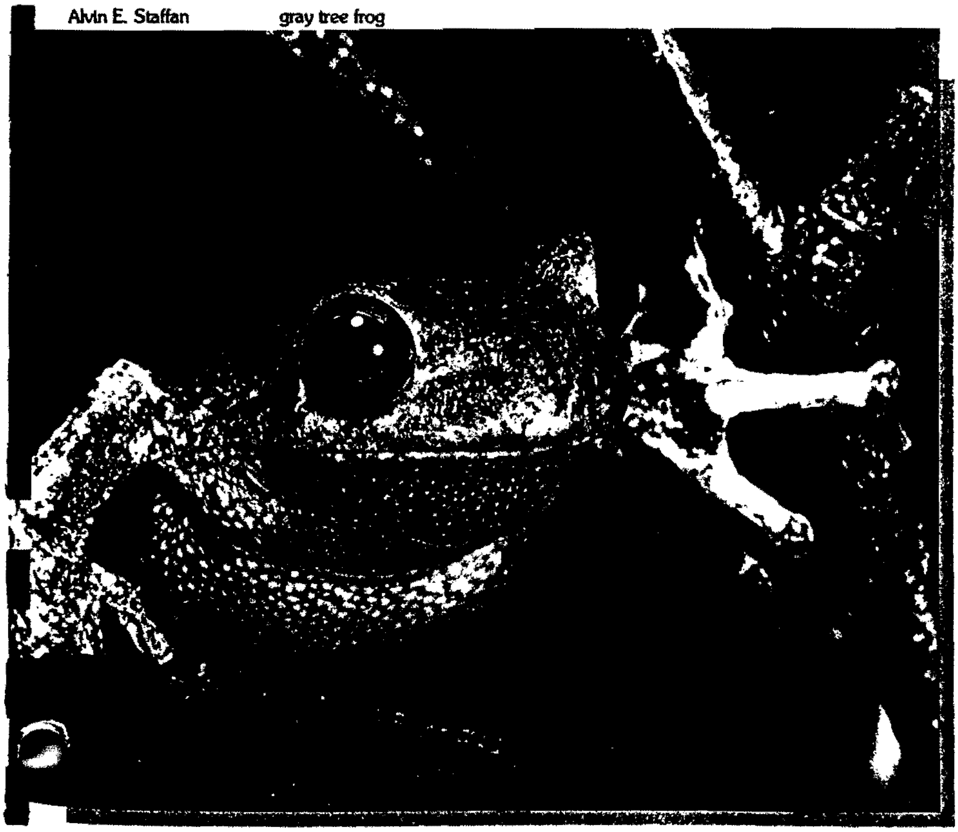
Objective:
Describe several characteristics that help some amphibians survive.

Ages:
Primary

Materials:
- ***copies of pages 33 and 34***
- ***large sheets of construction paper***
- ***glue***
- ***scissors***
- ***pictures of gray tree frogs, mudpuppies, and other amphibians***

Subject:
Science

Alvin E. Staffan gray tree frog



Have your kids focus on two amphibians—gray tree frogs and mudpuppies—to learn about some of the adaptations that help amphibians stay alive.

Begin by explaining the concept of adaptation to the kids. Explain that all living things have special features, or *adaptations,* that help them survive. For example, a giraffe's long neck helps it reach the treetop leaves that it eats. A lion's sharp claws and teeth help it catch and kill its prey. And a duck's webbed feet help it swim.

Now pass out copies of page 34 to the kids. Explain that both of the animals shown on the page are amphibians. (You may want to use the background information on pages 19-22 to discuss the characteristics of amphibians. See "Hands-On Herps" on page 7 for more about amphibian characteristics. You can also show them pictures of different kinds of amphibians.) Have the kids look at the pictures on the Copycat Page and describe what type of habitat each one of the animals lives in. (mudpuppies live in rivers, streams, ponds, and lakes; gray tree frogs spend most of their time in trees) Then tell them that, like other living things, these two amphibians have special features that help them survive where they live. The kids will be finding out about these features.

Pass out scissors, glue, and two sheets of construction paper to each child. Have them cut apart the pictures on their Copycat Pages and glue each one to the middle of a separate piece of construction paper. Now pass out copies of page 33. Explain that all of the pictures on this page show close-ups of parts of either the mudpuppy or the gray tree frog. Have the kids cut the pictures apart and put them in a pile, in order from "A" to "G." ("A" should be on the top of the pile.)

Now have the kids look at picture A. Ask them which amphibian this part is from and what part of the body it is. (gray tree frog's legs) Then, using the information under "Prime Parts" on the next page, discuss with the kids how a gray tree frog's legs help it survive in the trees. Afterward have them glue picture A beside the gray tree frog and draw a line from it to the frog's legs. Next have the kids look at picture B. Again have them find which animal the part is from (gray tree frog's toes) and then use the information on the next page to talk about how this special feature helps the animal survive. Afterward they can glue picture B in place, draw a line connecting it with the frog's toes, and move on to picture C.

When you've finished talking about all of the pictures, review each amphibian with the kids. (See the information under "Facts About Tree Frogs and Mudpuppies" on the next page.) You might also want to mention that both of these amphibians have skin colors and patterns that help them blend into the background. A gray tree frog's skin can even change color to match the color of the leaves or bark it's sitting on.

Then tell them that these animals have a lot in common with other kinds of frogs and salamanders. Show them pictures of other frogs and salamanders and have the kids point out similarities and differences.

(continued next page)

PRIME PARTS

A. *Long Legs:* Like many frogs, gray tree frogs have long, strong hind legs for jumping and climbing. They can leap more than 2½ feet (75 cm) in a single jump! These legs help them catch food and escape predators.
B. *Gripping Toes:* At the ends of their toes, gray tree frogs (and most other tree frogs) have broad discs that act like suction cups to help them get a good grip on leaves, branches, and other objects. These discs also secrete a sticky substance that works like glue to help the frog hold on.
C. *Thick, Flat Tail:* Like many other salamanders that live in the water, mudpuppies have a thick tail that's flattened sideways. The mudpuppy swims by moving its tail from side to side.
D. *Feathery Gills:* With its large, feathery gills, a mudpuppy can get oxygen directly from the water. And, like most other amphibians, mudpuppies can also absorb oxygen through their skin. In water without much oxygen, mudpuppies swim to the surface of the water and use their lungs to breathe air.
E. *"Eagle" Eyes:* Like most other frogs, gray tree frogs have large eyes that stick up on either side of their head. With its eyes a gray tree frog can watch for prey and predators in all directions at once.
F. *Outside Eardrums:* The circular piece of skin located behind each of the tree frog's eyes is an eardrum, or *tympanum*. A gray tree frog hears when sound waves strike its tympanum. Hearing is especially important for gray tree frogs during the breeding season when the males call to attract females.
G. *Salamander Senses:* Unlike gray tree frogs, mudpuppies have small eyes. But being able to see well is not as important for them since they live in water that is often dark and murky. Instead they rely more on their sense of smell and touch. Two nostrils on their head help them smell prey in the water. And special organs along their head, sides, and tail detect the movement of predators or prey.

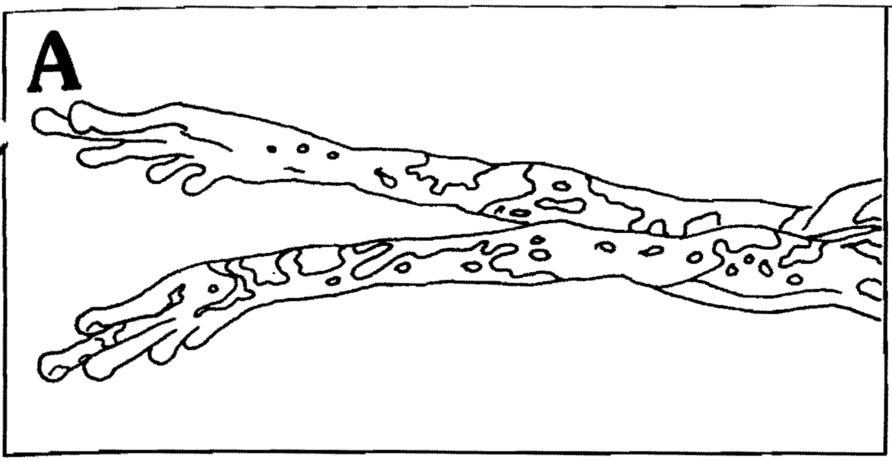
FACTS ABOUT TREE FROGS AND MUDPUPPIES

Gray Tree Frogs

- grow to be a little over two inches (5 cm) long
- feed on all kinds of insects including flies, ants, and beetles, as well as spiders and other small invertebrates
- have moist bellies and legs that help them hold onto leaves and other surfaces

Mudpuppies

- grow to be 17 inches (43 cm) long
- feed on fish, frog eggs, snails, insect larvae, and other aquatic animals
- usually hide under rocks and debris during the day and come out at night to hunt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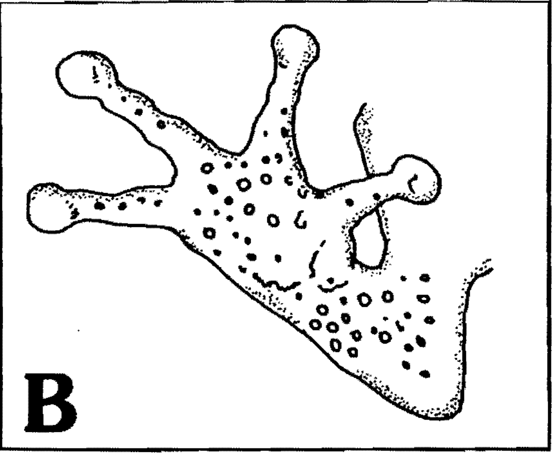
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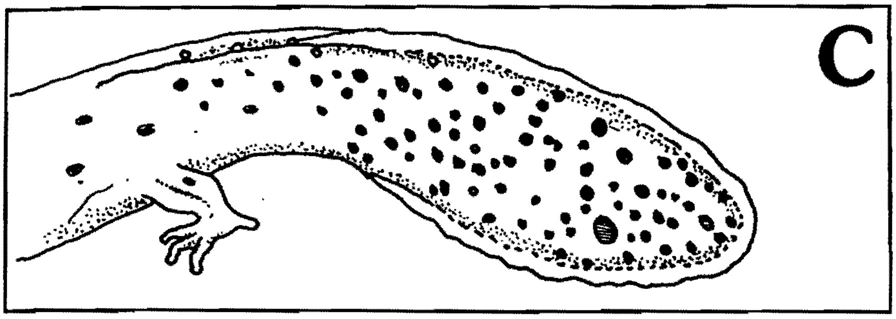
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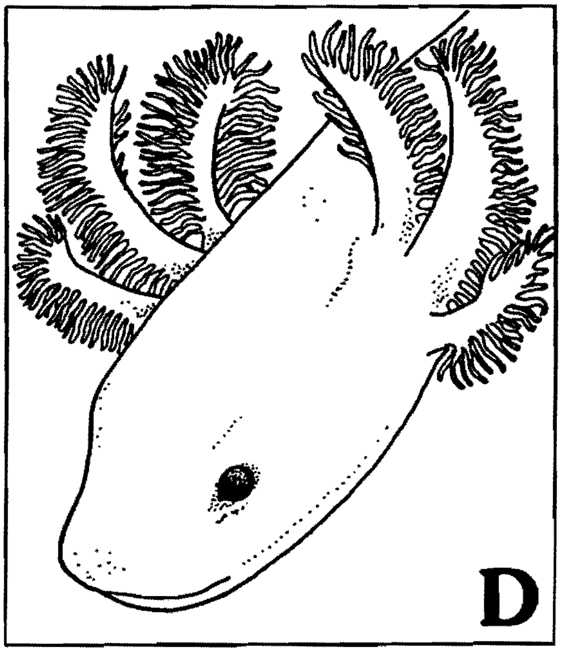
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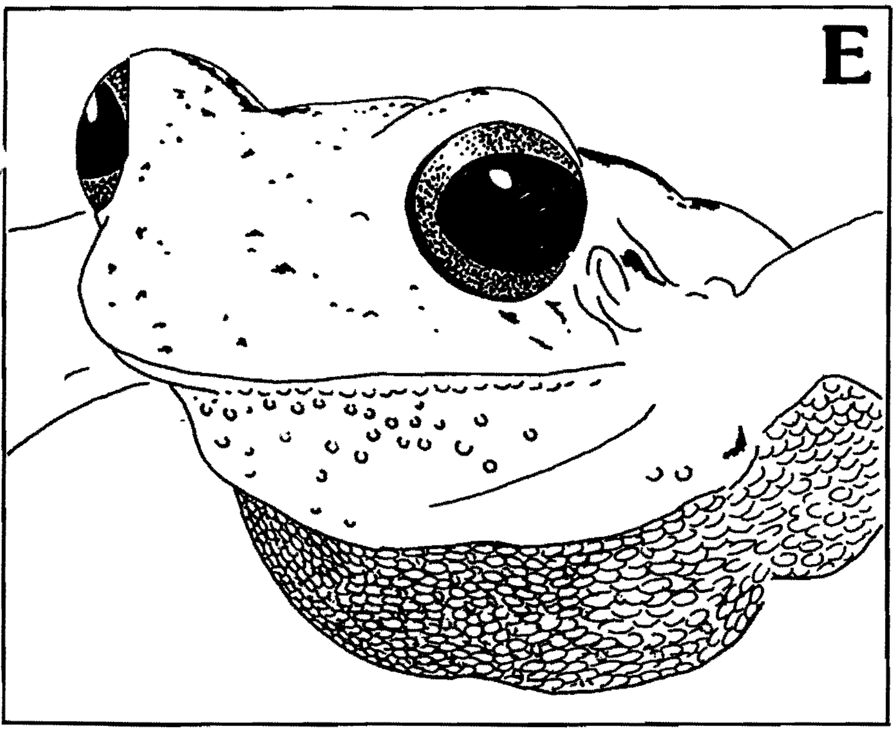
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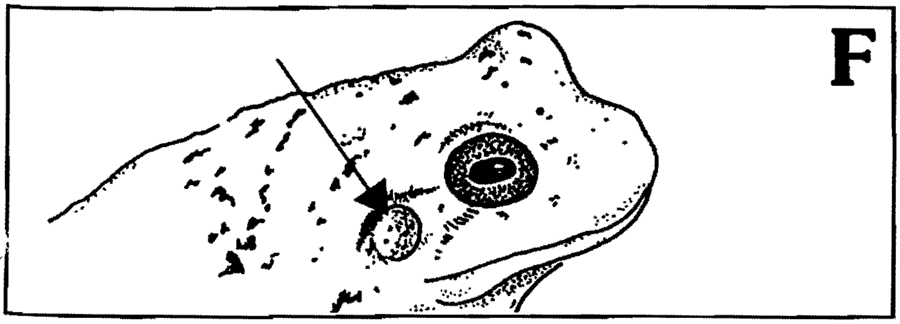
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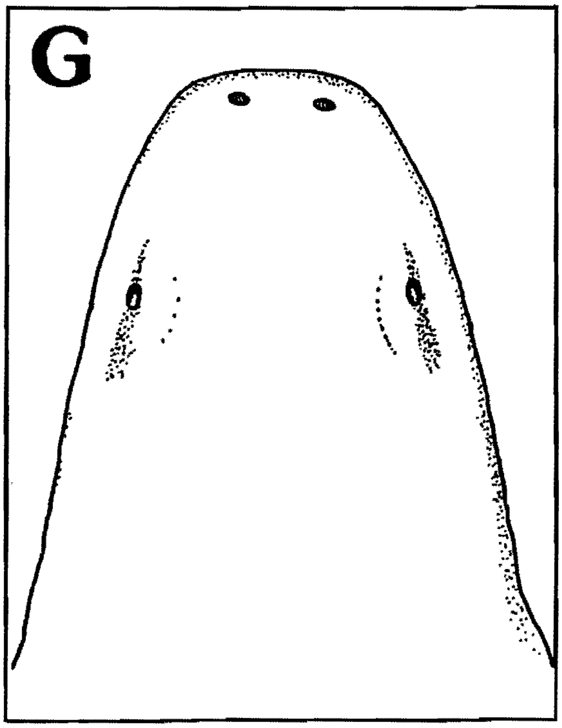
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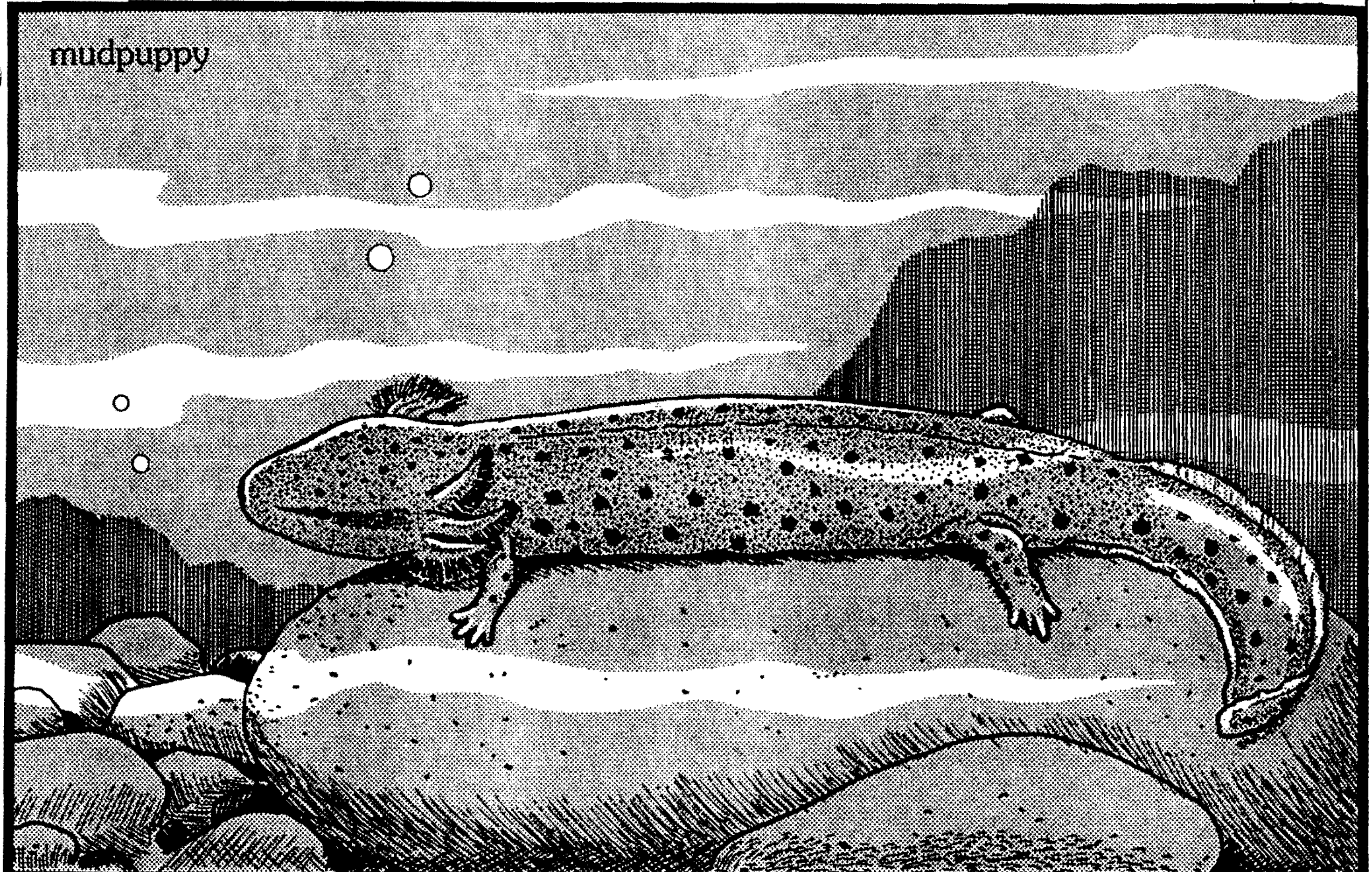
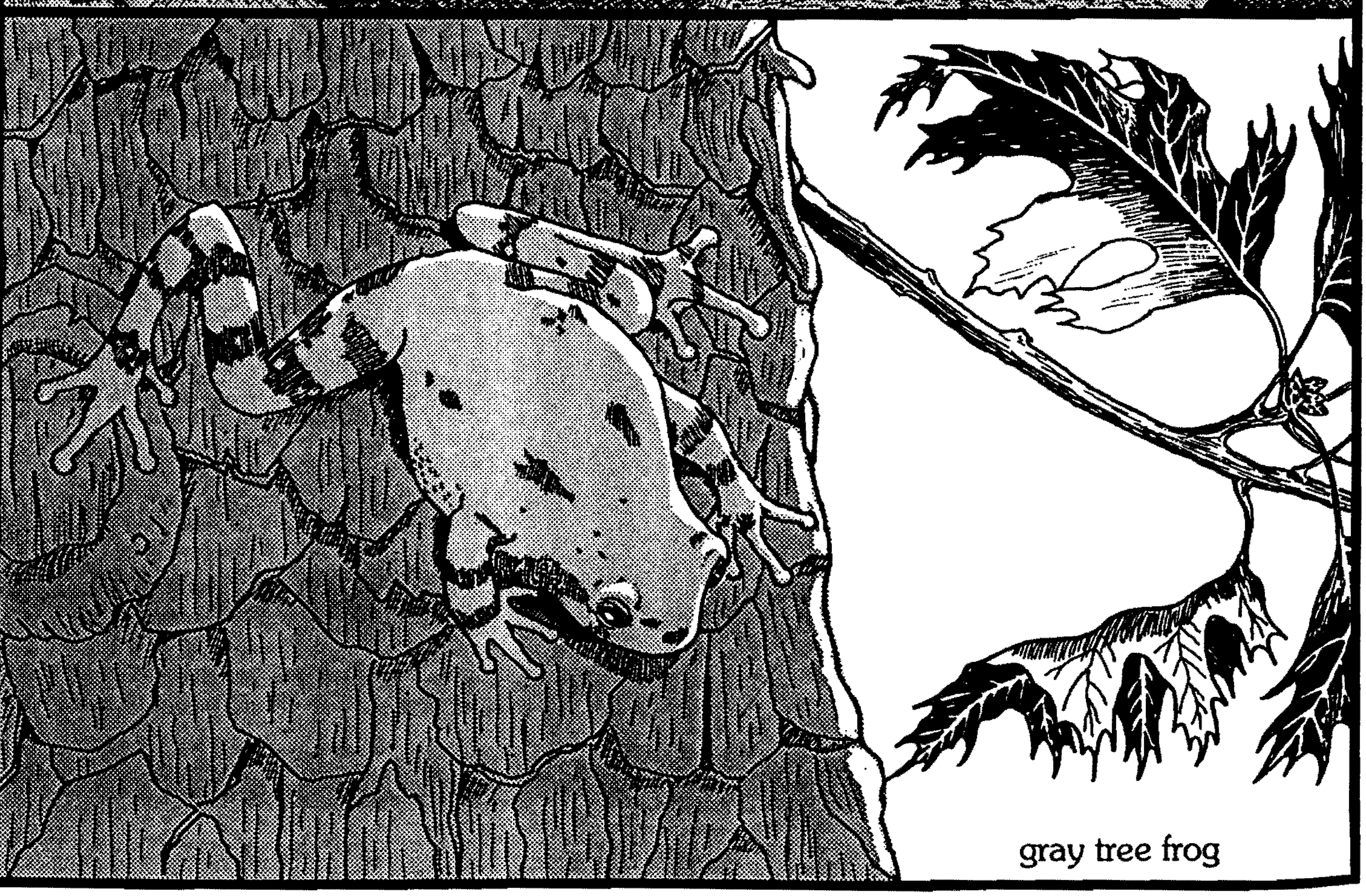

mudpuppy


gray tree frog

Hot 'n' Cool Herps

Keep a "thermometer lizard" within a certain temperature range.

Objectives:
Define the terms cold-blooded, warm-blooded, ectotherm, and endotherm. Describe the behaviors that some reptiles and amphibians use to regulate their body temperatures.

Ages:
Intermediate and Advanced

Materials:
- ***sunny day***
- ***thermometers with metal backings***
- ***slips of paper***
- ***chalkboard or easel paper***

Some reptiles and amphibians keep their body temperatures within a "preferred" temperature range. For example, the desert iguana usually keeps its temperature between 104° and 106° F (40° and 41° C), and the rose-bellied lizard's temperature usually doesn't vary more than a degree or two from 98° F (37° C). How do they do it? Most herps use a variety of techniques, such as basking in the sun when cool and retreating to shade or burrowing underground when hot, to stay within their preferred range. In this activity your kids can use "thermometer lizards" to discover for themselves how herps control their body temperatures. (*Note:* This activity will work best on a sunny day.) Here's how to do it:

GETTING READY

1. Choose an area with a mixture of sunny and shady places. There should be enough room for the kids to spread out. Take temperatures around the area to find the lowest and highest temperatures. Allow enough time for the thermometer readings to stabilize (about two minutes) before you record the temperatures. (*Note:* The highest and lowest temperatures should be taken no more than one hour from the time that the kids start using their thermometers.)
2. Next decide on a series of five-degree temperature ranges. The lower limit of the first range should be five degrees below the coldest temperature you recorded. (For example, if your lowest temperature was 60° F, the first range would be 55-59° F.) Continue making

Subject: Science

non-overlapping five-degree ranges until you've reached a temperature that is five degrees warmer than the highest temperature you recorded (see example in lower margin).

3. Assign each temperature range to an imaginary lizard (for example, Lizard A would have a temperature interval of 55-59° F). Then copy each lizard's letter and its temperature range on a separate slip of paper.
4. Later you'll assign a range to each pair of kids in your group. If you have a large group, you can assign more than one pair to a range. And if you have more ranges than pairs of kids, leave out some of the middle ranges.

Indian house gecko

INTRODUCING YOUR KIDS TO THE LIZARDS

Use the information under "External Energy" on page 3 and the information under "The Ups and Downs of Temperature Control" on page 12 to discuss the terms *cold-blooded, warm-blooded, ectotherm,* and *endotherm* and how they relate to amphibians and reptiles. Then divide the kids into pairs and tell them that each pair will pretend their thermometer is a different type of lizard. Also explain what a preferred temperature range is and what happens if a lizard gets too hot or cold. Be sure to point out that although many herps have a preferred range, the kids will be focusing on lizards because they're some of the "best" temperature regulators. But also explain that not all lizards have a narrow preferred range.

Next give each team a thermometer and one of the lizard slips that you made earlier. Tell the kids that they will be going outside to try to find places where they can keep their lizards within their preferred range.

Ask the kids if they can think of some ways to regulate their lizard's body temperature. (Encourage them to be creative, but don't tell them what techniques to use.) The kids may come up with ideas such as putting the thermometer in direct sun; alternating it between shade and sun; keeping it in cool, shady areas; putting it underground; or looking for areas with no grass that will be very hot.

Also point out that, depending on their lizard's range, they'll probably have to use different techniques to stay within range. Some teams might be able to find one spot and stay there, but others may have to move from place to place to keep their temperatures in range. And some may not be able to stay within their range at all.

SETTING UP TEMPERATURE RANGES

lowest temperature measured: 60° F
highest temperature measured: 100° F

RANGES (° F)
55-59
60-64
65-69
70-74
75-79
80-84
85-89
90-94
95-99
100-104
105-109

LIZARDS IN ACTION

Have the teams spread out over the area and start taking temperatures. Emphasize that they should get their temperatures within their preferred range and keep them in range until time is up. (You may want to set a time limit of about 10 minutes for the teams to get within range.)

Give them these tips to follow as they take temperatures:

- Leave the thermometers in place for at least a minute so they will register an accurate temperature.
- Touch only the metal backing, not the bulbs of the thermometers.
- Keep the thermometers close to the ground or other surfaces to avoid taking air temperatures.

BACK INSIDE: WHO MADE IT?

Copy the chart in the upper margin of the next page on a chalkboard or piece of easel paper. Then fill in the information as a group, using the following questions to discuss what happened.

- Which lizards were able to stay within their preferred range? Have the "successful" pairs describe how they kept their thermometers within range.

(continued next page)

- Which lizards might have a tough time surviving in your area? (The ones with the lowest ranges probably couldn't survive above ground, and the ones with the highest ranges might find even the open areas to be too cool.)
- Depending on the time of year and where you live, some lizards may have been assigned temperature ranges as high as 120–124° F (49–51° C). Ask the kids if they think many real lizards have a preferred temperature range that's so high. (No. Most lizards can't survive if their body temperature reaches more than 115° F [46° C]. And if they can, it's only for a short time.)
- If none of the teams tried less obvious techniques, such as placing their thermometer lizards underground or under leaves, take them back outside for another try after the discussion. For example, have them take temperatures at different ground depths, and see if the team with the lowest temperature interval could stay "in-bounds" by burrowing.

SAMPLE CHART

LIZARD	RANGE (° F)	DID IT STAY IN RANGE?	WHERE DID YOU PUT IT?
A	55-59	no	under a bush
B	60-64	yes	in shady grass

THE UPS AND DOWNS OF TEMPERATURE CONTROL

- Most amphibians and reptiles instinctively keep their body temperatures within a specific temperature range. This is called their *preferred range* or *normal activity range.* To be active (i.e., find and digest food, escape from predators, and so on) a herp must stay within this range. If its body gets too hot or too cold, the animal won't function as well as it should. And if its body temperature goes above a *critical maximum* or below a *critical minimum,* it won't be able to move at all and will eventually die from the extreme temperature.
- A herp's preferred temperature range is related to where it lives. Reptiles and amphibians that live in cooler places, such as high altitude forests, have lower preferred ranges. And those with higher preferred ranges are found in warmer areas, such as deserts.
- In general, amphibians have lower preferred ranges than reptiles. And many amphibians don't keep their body temperatures as constant as some reptiles do.
- Many reptiles, especially some lizards, have narrow preferred ranges and behave in ways that keep their bodies at an almost constant temperature.

Luise Woelflein

TEMPERATURE TACTICS

Different kinds of herps use different combinations of the "tactics" listed below to stay within their preferred range. For example, most snakes can't change color, but they do burrow and/or bask.

Sun and Shade: Alternating between hot, sunny areas and cool, shady spots is the most common way that reptiles control their body temperature.

Many amphibians also bask in the sun to warm up. But, since they are vulnerable to water loss through their skin, amphibians usually bask only if they're in a moist place where they can replenish lost water.

It's All in the Timing: Some herps are active only when the temperature is "right." For example, many desert-dwelling reptiles are active at night or in the early morning to avoid scorching daytime temperatures.

Underground: Many amphibians and reptiles retreat to cool burrows when daytime temperatures get too hot. They also go underground at night, when burrows are warmer than the air above ground.

Color Changes: By changing the color of their skin, many herps can adjust the amount of heat they absorb from the sun. (Dark surfaces absorb more of the sun's rays than lighter surfaces.)

Body Basics: Some reptiles adjust the position of their bodies to heat up or cool down. For example, marine iguanas press their bodies against warm rock to warm up after a cold swim. If they get too warm, they raise their bodies away from the hot surface and cool off in the breeze.

Water Dwellers: Turtles, frogs, and alligators may warm up in shallow water that has been heated by the sun. To cool off, they can move to deeper, colder water.

"Hot 'n' Cool Herps" was adapted with permission from an activity called "Cool It" by OBIS (Outdoor Biology Instructional Strategies).

Habitat Exploration

Objectives:
- Distinguish between living and nonliving things
- Explore and document the needs of various plants and animals in certain habitats
- Engage in a variety of scientific investigations into animal and plant adaptations to their environments
- Use a variety of devices to obtain information from different habitats
- Discuss ways in which pollution affects the environment
- Observe the sequence of succession

What to Teach	Teaching Suggestion
Build a terrarium.	- Refer to the enclosed lesson plans entitled "Building a Mini-World"
Discuss the interactions of soil, plants, water, and sunlight as relating to the terrarium and the lesson plans.	- Use the terrarium as a model to discuss these interactions on a larger scale.
Discuss the needs of living things.	- Question students by referring back to the plants in the terrarium, or even to their own needs. Q: What do we need to live? - Answer: Everything needs water, air, sunlight, and space. <u>water</u> - everything needs water to drink, the body is comprised of 65% water <u>air</u> - we need oxygen to breathe, plants need carbon dioxide <u>sunlight</u> - plants need sunlight to grow, we need it to grow plants to consume <u>space</u> - every living thing needs room to grow and move
Student activity.	- See "What's That, Habitat?"

What to Teach	Teaching Suggestion
List what is living and not living in the terrarium. How can you tell that one thing is living and another isn't?	What is "living"? -- the ability to grow and change -- the ability to react to the surrounding environment -- the need for energy or food -- the process of taking in gases for respiration -- the ability to reproduce -- being made up of cells Q: Is a river living? (no) What about a tree? (yes) Or, this apple? (no)
Discuss how the terrarium will change over time.	- How will the terrarium change as it grows? (see "Forest Succession: The Changing Land") - Discuss the concept of succession and change. We grow and change, so does the land, and the terrarium.
Q: What different communities, or habitats, are found in Ohio? <u>Community</u> - everything, living and nonliving, residing in a certain area.	- grassland or field community - successional areas - forest community - pond or aquatic community
Q: Do different animals live in different communities or do all communities support different types of animals?	- Different animals are adapted to, or better suited to, certain areas. - Q: Could a deer live in the pond? Could a fish live in the forest? Could a turkey live in a field? - No, the food they eat isn't there and they would have no place to hide from predators.
Discuss (in depth) the different communities of Sharon Woods and what plants and animals can be found in each one.	- Refer to the activity pages titled "Grassland Community", "Successional Area", "Forest Community" and "Pond Community" - Have the students complete the related activities in each section.

What to Teach	Teaching Suggestion
Student activity.	- Have each student do a report or project on one animal that is found in Ohio, including where the animal lives and how it has adapted.
Visit to Sharon Woods Metro Park.	**- Students will explore the woods, ponds, and successional areas of Sharon Woods. The naturalist will take students on a walk to discuss the four areas, what animals live in each area, and how those animals and plants have adapted to living there (ie. reliance on food, cover, lifestyle). Students may also be provided with time to explore the different areas using equipment such as thermometers, compasses, and soil probes.**
Conduct a habitat investigation.	- Follow the guidelines and use the handouts provided under "Habitat Study" - The habitat investigation can either be done at the park in conjunction with the visit (if time permits) or it can be done around the school yard.
Make a comparison chart of the different habitats.	- Again, follow the directions Discussed in "Activities With Habitats". Compare and contrast what was seen.
Discuss the effects of human interactions activity on the environment.	- Use "Pollution Pursuits" for ideas. Have students discuss pollution/trash they found while in the park, around the school, or while walking home.
Question students	Q: How might this trash affect the animals that live around the area? Q: How will pollution affect animal populations in the long run?

What to Teach	Teaching Suggestion
Art project and activities	- Have students make a cardboard community. See that and other ideas under "Creative Dramatics"

Building a Mini-World

Interest Approach

You've probably all heard about the environment and how it is important to not pollute it. But, what makes up the environment around us?
(Possible student responses)

a. water
b. dirt
c. trees
d. animals
e. land

These are all called natural resources of the land. They are part of the natural world surrounding us and are used by everyone and everything that is around.

Have you ever wondered about how important these natural resources and natural systems, such as the environment, are? What are they important for?
(Possible student responses)

a. They provide us with what we need to live.
b. Animals live there and get all their food from the environment.
c. We don't want to pollute them because it is bad.
d. We use the resources to make stuff.
e. Plants need the soil and the water to live.

Everything around us works together and depends on everything else. Plants depend on the soil for food; animals depend on the plants; we depend on the animals. Plants also depend on sun and water; animals depend on water and hiding places; we depend on the land for food, oil, and water.

We can build a small environment that has everything it depends on or needs to work right here in class. (Show example of terrarium.) This is called a terrarium and is a self-contained environment. It contains soil, plants, and water and uses the sun that comes through the window to aid in growing. Let's see how it and the environment work...

SET UP A TERRARIUM

LEVEL: Pathfinder (low; 1 hour set-up)

SEASONS: All, but especially fun in winter

MATERIALS:

Large, clear glass or plastic container with a wide opening (container should hold 1 gallon or more and be about 8 tall, either upright or on its side); an unused aquarium with a glass top may also be used
Watertight stopper/cover (glass, cork, plastic wrap and rubber band, etc.)
Small plants that do not need direct sunlight (see list)
Sterile potting soil
Sand
Crushed charcoal (available at aquarium supply stores, or use barbecue charcoal, but not the match-lighting kind)
Gravel or pebbles

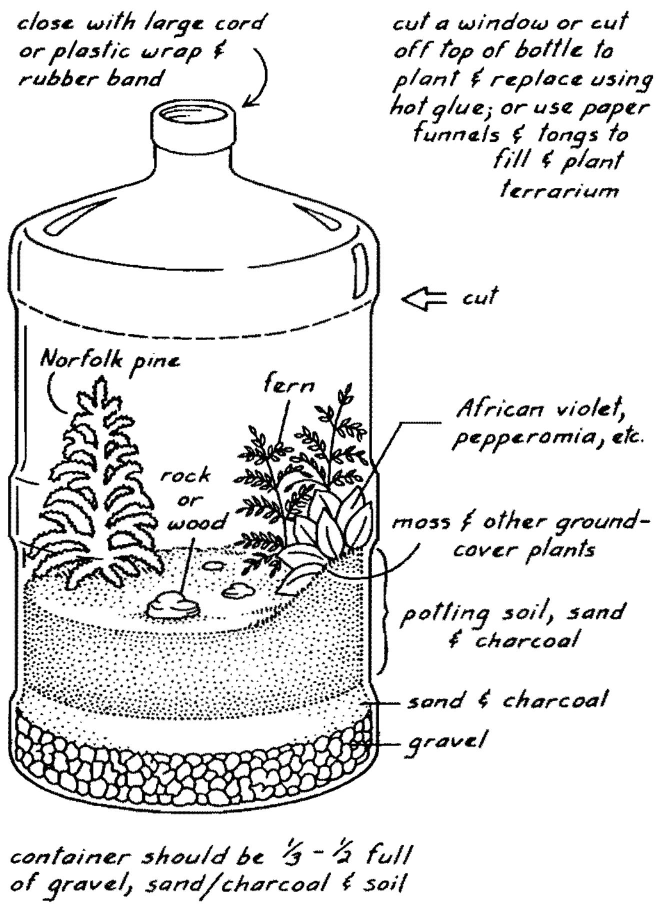
INTRODUCTION

For all practical purposes, our planet is a closed system, which means that all the water, air, and natural resources in it are irreplaceable. The earth can create plenty of air, *only if* we maintain the quality of the water, soil, atmosphere, and climate that plants rely on to produce oxygen.

When people say that all life is interconnected, they mean that each organism affects others, and these in turn affect still others. Life forms a complicated web—even minor changes can have unforeseen consequences.

A terrarium can be closed or ventilated. And we have the luxury of changing its conditions to correct for loss of water, overpopulation, or other threats to the system's health. When closed, water circulates through the system as it is drawn up by plant roots, passes through trunks and stems into leaves, and is released as vapor. The vapor condenses into droplets that fall to the ground, where they pass through the soil, losing impurities along the way, and eventually are recaptured by thirsty roots. The plants take carbon dioxide from the air and give off oxygen during the day; at night, they may also release excess carbon dioxide.

A terrarium illustrates both the earth's water cycle and how plants can survive in a balanced, closed system. A terrarium is not only a model for an individual ecosystem, but a symbol of our planet and the need to conserve and preserve its limited resources.



Terrarium made from a plastic, 5-gallon water bottle

This terrarium could also have been planted in an upright position.

STEPS

1. Clean the container and rinse the gravel and charcoal. Decide how to orient your container—some can be planted either on a side or standing upright.
2. Spread a 1-inch layer of gravel in the bottom, and cover it with a ½-inch layer of sand and charcoal. Save some charcoal and sand to mix with your potting soil. These will help filter out impurities in the water and ensure good drainage. Cover the foundation of gravel, sand, and charcoal with about 2 inches of potting soil. Your container should be about a third of the way full now.
3. You may want to sketch out a planting plan before you start, or trace a floor plan of your container and arrange the potted plants on that.
4. To plant, loosen the soil around the roots, make a shallow hole in the soil, and pack the soil firmly around the stem. When planting is complete, water just enough to moisten the soil. Stop if you notice water collecting at the bottom.
5. Close the system with a lid, cover, or clear plastic wrap secured by a rubber band.
6. Put your terrarium in a shady spot for a day or two, then move it to an area that receives plenty of *indirect* light. Too much direct sun will fog up the system and cook the contents.

Beads of water should collect on the sides of the terrarium; if the sides completely fog up, open the container for a few hours to release some of the water. Because your terrarium is not completely closed, you may need to add a little water once in a while, but don't overdo it. Overwatering is more dangerous than underwatering. If you don't notice any beads of water for a week or so, feel the soil. If it's dry, add some water.

Plants for Terrariums

The best terrarium plants are slow-growing and moisture-loving. They also should thrive without direct sunlight. Many tropical plants are well suited to low light levels and high humidity. Ask someone at your local plant store for guidance. Some good choices follow:

Trees and shrubs (for larger terrariums)
Boxwood, Chinese evergreen, dwarf palm, hemlock, Norfolk pine

Ground cover
Creeping charlie, aluminum plant, moss, small-leaved ivy

Plants
African violet, artillery, fittonia, miniature geranium, partridgeberry, pepperomia, prayer, small-leaved philodendron, strawberry begonia, wintergreen

FIND OUT MORE

See Virginie Elbert and George A. Elbert, *Fun with Terrarium Gardening* (New York: Crown Publishers, 1973) (out of print; look for it in your library).

Tips and Tidbits

Different-sized terrarium containers need different amounts of drainage material and soil, but the proportions should remain roughly the same: Fill no more than the bottom fifth of the container with gravel, and cover that with a thin layer of sand and charcoal. Your container should be about a quarter full. Now add soil until the container is about two-fifths full.

The greatest challenge to setting up a terrarium is balancing the water level. Too much, and the vegetation will rot; too little, and it will dry out.

A recycled terrarium can be made from a clear plastic, 2-liter soda bottle (the ones with the black base). Remove the base and plug the holes with tape or hot glue. Fill the base nearly to the top with proportional amounts of charcoal, gravel, and soil, and add plants and water. Cut off the funnel-shaped top (a few inches below the spout), wash it, and turn the cylinder upside down to close the terrarium. Use tape or hot glue to seal it.

A large, plastic, wide-mouthed pretzel barrel or pickle jar also makes a good terrarium.

WHAT'S THAT, HABITAT?

Objectives
Students will be able to: 1) identify their own basic needs for food, water, shelter, and space in a suitable arrangement; and 2) generalize that wildlife and other animals have similar basic needs.

Method
Students draw pictures of people's and animal's homes, comparing basic needs.

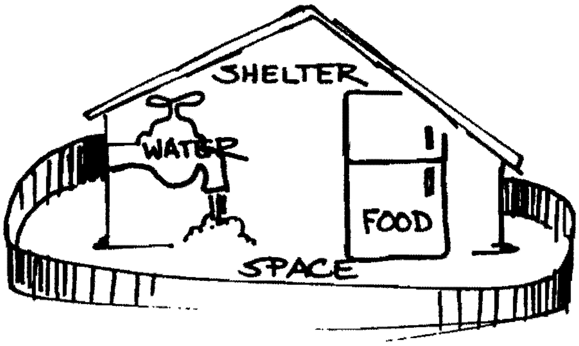
Background
This activity is similar to "Habitracks." One option is to use "Habitracks" with 4th and 5th grade students, and "What's That, Habitat?" with 2nd and 3rd grade students. Use either activity after "The Beautiful Basics" and "Everybody Needs A Home," especially with 2nd grade students and older. The same drawing used in "Everybody Needs A Home" can be used to start "What's That, Habitat?"

See "The Beautiful Basics" and "Everybody Needs A Home" for more background.

The major purpose of this activity is for students to understand that animals—including people, pets, and wildlife—have some of the same basic needs.

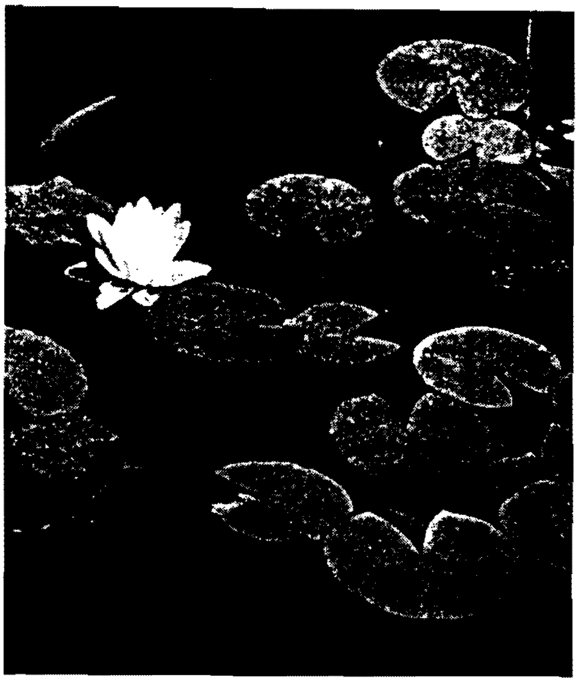
Materials
drawing paper, crayons or chalk

Procedure
1. List the following words on a chalkboard: **food, water, shelter, space.**
2. Read each word aloud, asking the students to repeat the words after you. (They may say the letters of the words and use for spelling.)
3. Food and water will be easy concepts for the students to understand. They are familiar needs for themselves each day. Shelter and space will be more difficult. Ask the students to explain what shelter and space are. Make sure the meaning of all four words is clear before you proceed.
4. Give the students drawing paper and chalks or crayons. Ask the students to draw a picture of where they live, including pictures of where they find food, water, shelter, and space. (NOTE: If the students have made drawings in "Everybody Needs A Home," use those same drawings instead of making new ones!) Ask the students to label the parts of their drawings where they find their **food, water, shelter,** and **space.** For example:



NOTE: Food and water will not be difficult to identify. Shelter could be shown in a number of ways. Here, for example, it is shown by labeling the roof. Space can be shown as the area outside and inside the house or apartment. Shown here, it includes the house and yard. Space can also include the neighborhood. (Space actually includes all the areas used for survival.)
5. Once the drawings are complete, write two more words on the chalkboard: **arrangement, habitat.** Say the words aloud, asking the children to repeat them after you. (Again, these words may be used for spelling.)

Age: Grades 2—3
Subjects: Science, Language Arts, Art, Social Studies
Skills: analysis, comparing similarities and differences, discussion, drawing, generalization, reading, writing
Duration: two 20-minute sessions, or one 40-minute session
Group Size: any
Setting: indoors
Conceptual Framework Reference: I.A., I.A.4., I.C.1., I.C.2
Key Vocabulary: habitat, survival needs, food, water, shelter, space, arrangement



6. Tell the students that when food, water, shelter, and space go together in a special way, so that animals—including people—can live, we call that place a **habitat**. The food, water, shelter, and space are in an **arrangement** that makes it possible for animals to live. (Optional: Ask the children if they could live in a home where the bathroom was four miles north, the kitchen was 12 miles west, and the bedroom was nine miles east. The answer, of course, is likely, "No," since the "arrangement" is not suitable for a person. Some animals, do travel great distances in their habitat, however.)

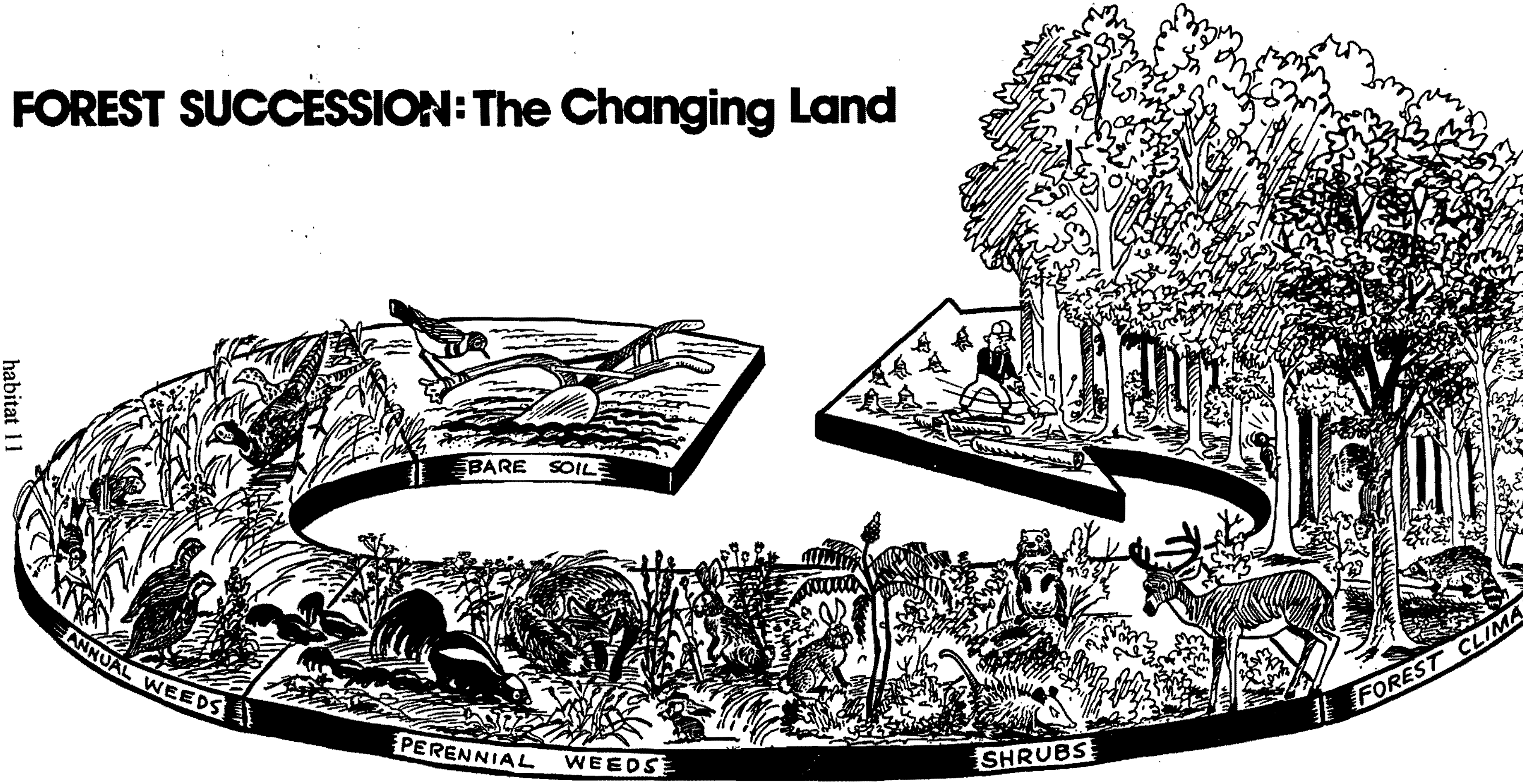
7. Ask the students to write the word "habitat" in big letters at the top of their drawings. Talk with them about the meaning of habitat.
8. Give the students another piece of drawing paper. Ask them to think of an animal—any animal. Ask a few students what animal they are thinking of. Identify whether the animals they named are "wild" or "domesticated." You will probably get both. If you don't get both, ask the students to think of the kinds of animals that are missing. It is important to make sure the students are thinking about both wild and domesticated animals.
9. Ask the students to draw a picture of their animal in a place where it lives. Ask the students to make sure they include: food, water, shelter, and space in an arrangement that they think would make it possible for the animal to survive.
10. Ask the students to talk about their drawings, pointing out the habitat components they have included.
11. Ask the students to write "habitat" in big letters on the top of their drawing. Talk with the students about how humans and other animals need food, water, shelter, and space. The arrangement is different for each, but all have similar basic needs. When food, water, shelter, and space are arranged in a way that is suitable for an animal to survive, we call that place where these things are available a habitat. When the students have an understanding of "habitat," write a few sentences on the chalkboard defining habitat. As much as possible, make use of the ideas the students suggest. For example: **Habitat is a place. It has food, water, shelter, and space. These are things that animals need to live.**
Possible sentences for older students: **Food, water, and shelter must be within a useable range for each animal. Different kinds of animals need different kinds of food, water, and shelter and different amounts of space.**
12. The students may now write these sentences on the back of one of their drawings or on a piece of writing paper. They may also read the words in the sentences you have put on the board, after you. They may also write their own sentences about what habitat is, drawing pictures to go along with their words.

Evaluation

Choose which things wildlife need to survive: food, water, shelter, space, arrangement.

Choose which things people need to survive: food, water, shelter, space, arrangement.

FOREST SUCCESSION: The Changing Land



Michigan Forest Succession

Change. In Michigan our forests have undergone centuries of change. This change is called **Succession,** the orderly replacement of one plant community by another. Along with the plant communities, the wildlife that inhabits these areas will change, too. This change takes place over a long period of time and can occur naturally or with human interference.

Long before Michigan was settled, our state was covered almost entirely by forests. On occasion a bolt of lightning would ignite a forest fire and the burned timber would create a place for a new plant community. The same would happen if an ice storm or tornado destroyed parts of the forest. As the new plant community became established, the wildlife adapted to the change.

As Michigan began to become more populated and settlement occurred, it was human interference that added a new dimension to succession. It was the axe, plow, and saw that changed the established forest communities. The building of towns, creation of farms, and logging of forests accelerated succession. Natural succession is good and because it takes time, most wildlife can adapt easily. When it occurs at too great a speed, succession can alter the natural habitat of wildlife species before they can adapt. Today forest and wildlife managers are aware of this concept. On the reverse of this page is an example of succession.

In this diagram, a farm has been deserted leaving only bare soil behind. Soon weeds spring up everywhere. Weeds are extremely important plants because they readily adapt to disturbance and rush in to fill a vacated niche. As the weeds become established they keep the soil from eroding. Without weeds, both wind and rain combine to remove the soil from the land. Without weeds, some of the rain that does fall quickly evaporates. The new weeds hold the moisture in place. As weeds die, their nutrients enrich the soil. Not many forms of wildlife live in bare soil, but as the weeds are taking over they produce food for seed-eating animals. Mice, gophers, quail, and pheasant are just a few of these.

After about fifteen years, the area now becomes dominated by shrubs. These sun-loving species of dogwood, sumac, blackberry, and hawthorn gradually replace many of the weeds and grasses. New mammals and birds (rabbits, groundhogs, bluebirds, etc.) that prefer more cover and eat parts of these plants will become more abundant. These animals bring new seeds along with them. Some of these seeds may have been eaten somewhere else, but are deposited here. Other seeds hitchhike on animals due to a prickly outer covering. Some seeds, such as acorns, may be deposited by squirrels from an adjacent forest. And, of course, many seeds arrive by the wind.

These new seeds may include some sun-loving tree species like aspen, black cherry, sassafras, or jack pine. These trees are often referred to as **pioneers** because they are the first trees to venture into these unclaimed territories. Pioneers love the sunlight and soon grow above the shrubs and now-disappearing weeds that cannot compete. The whitetail deer and ruffed grouse do exceptionally well in these early stages of pioneer species growth. After 35 years this young forest looks nothing like the farmland it had once been.

But succession doesn't stop there. Dependent on soil type, moisture, and seed availability, new species continue to move in and replace others. The young sun-loving pioneers will eventually have a difficult time replacing themselves in the now-shaded understory. Trees more tolerant of shade will become established. Oaks, hickorys, beech, and sugar maple can grow in less sunlight. In several hundred years, an initial forest of aspen and cherry may become a forest of sugar maple and beech.

As this forest become older, different wildlife species will choose it for habitat. If the browse line becomes too high and the forest floor too shaded for ground cover plants, the deer will become less abundant. Cavity-nesting animals drawn to older trees with decaying wood will be more common. Woodpeckers, raccoons, and squirrels are examples of these. The forest that grows old and allows only more of its own shade tolerant kind to grow is referred to as a **climax** forest. It may remain a climax forest for a very long time unless a farmer returns to cut down the trees, pull the stumps, and plow the soil. Remember, this is how our diagram began.

As we have seen, succession does not happen overnight. Yet, if you are observant, you can see the difference in plant communities and understand that wildlife is dependent of them. The meadow that children play baseball in today will no doubt grow into a forest tomorrow. It's only a matter of time . . . and change.

MUCC

MICHIGAN UNITED CONSERVATION CLUBS
2101 Wood St. ● P.O. Box 30235 ● Lansing, MI 48909 ● 517-371-1041

GRAPHANANIMAL

Objective Students will be able to identify characteristic life forms in two different environments.

Method Students create picture collections of animals in two different habitats, and then "visit" the habitats by going on a "nature walk" in their classroom, where they tally the number of animals they see and then graph and compare the results.

Background Different kinds of animals are found in different environments. Each environment is suitable to animals that are adapted to its climate, soils, water, vegetation, and other ecological factors. Just as people need food, water, shelter, and space in which to live, so does wildlife.

The major purpose of this activity is for students to recognize that each environment has characteristic life forms.

Materials photos or pictures of animals (from magazines), cardboard for mounting photos, notebook paper, graph paper, pencils

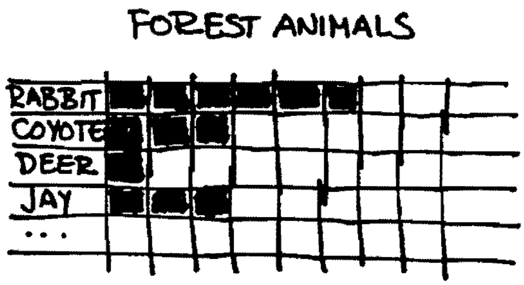
Procedure

1. Pick two environments in your state, such as the plains and the forest. Ask students to make a collection of animals for each place. They can draw pictures or cut out magazine photos. Each student should find two animals. Glue the pictures onto heavy paper or cardboard.
2. Ask the students to tell where their animals live. Make a pile for each place and ask the students to put their pictures in the place where their animals live.
3. List the animals in each pile. Some animals will appear on both lists. Ask the students to copy the two lists.
4. When the students are out of the room, place the animal cards in their "environment." Label one part of the classroom as forest, and the other as plains. Put the animals where they live. Some animals may be in both environments. Put the animal pictures in all sorts of places—by a table leg, on a window ledge, etc.—to simulate where they might actually live. If possible, check with fish and wildlife officials in your area to see what the actual proportions of animals are in each of the chosen environments, and use the animal cards accordingly. These people may also have wildlife pictures for various habitats!
5. Bring the students to the "forest" and the "plains" for a "nature walk." Let the students use their lists to tally the animals they see in each place. At the end of the walk, students should total their counts and write that number on their lists. Have the students take turns walking along the "path." A sample list and tally might look like this:

FOREST	TOTAL	PLAINS	TOTAL
RABBIT 卌 I	6	COYOTE 卌	5
COYOTE III	3	RATTLESNAKE III	3
DEER I	1	PRAIRIE DOG 卌 II	7
JAY III	3	ANTELOPE II	2

Age: Grades 2—6
Subjects: Science, Math (tally, addition, graph-making and use), Language Arts (word recognition and spelling)
Skills: analysis, classification, computation, kinesthetic concept development, listing, media construction (making and using simple bar graphs), observation, psychomotor development, reading, writing
Duration: two 30-minute periods; one 40-minute period if teacher prepares wildlife pictures
Group Size: 15 to 30 students
Setting: indoors or outdoors
Conceptual Framework Reference: III.A., III.A.1., III.A.3.
Key Vocabulary: environment, habitat, graph (as well as many different animal names)

6. Show the students how to make a bar graph for each of the environments:



Give the students graph paper and show them how they can fill in each square for the number of each animal they saw.

7. Using the graphs, compare the two environments: Which animals were seen the most? Which animals were seen the least? How could some animals live in both places? Why can't all the animals live in both places?

Variations

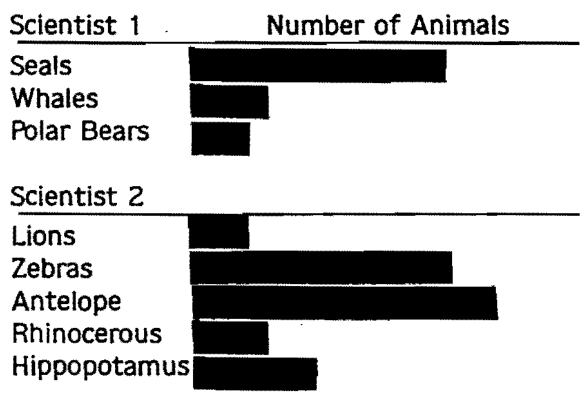
1. Skip having the students collect the animal pictures. If the teacher collects the photos, the activity may begin with the nature walk.

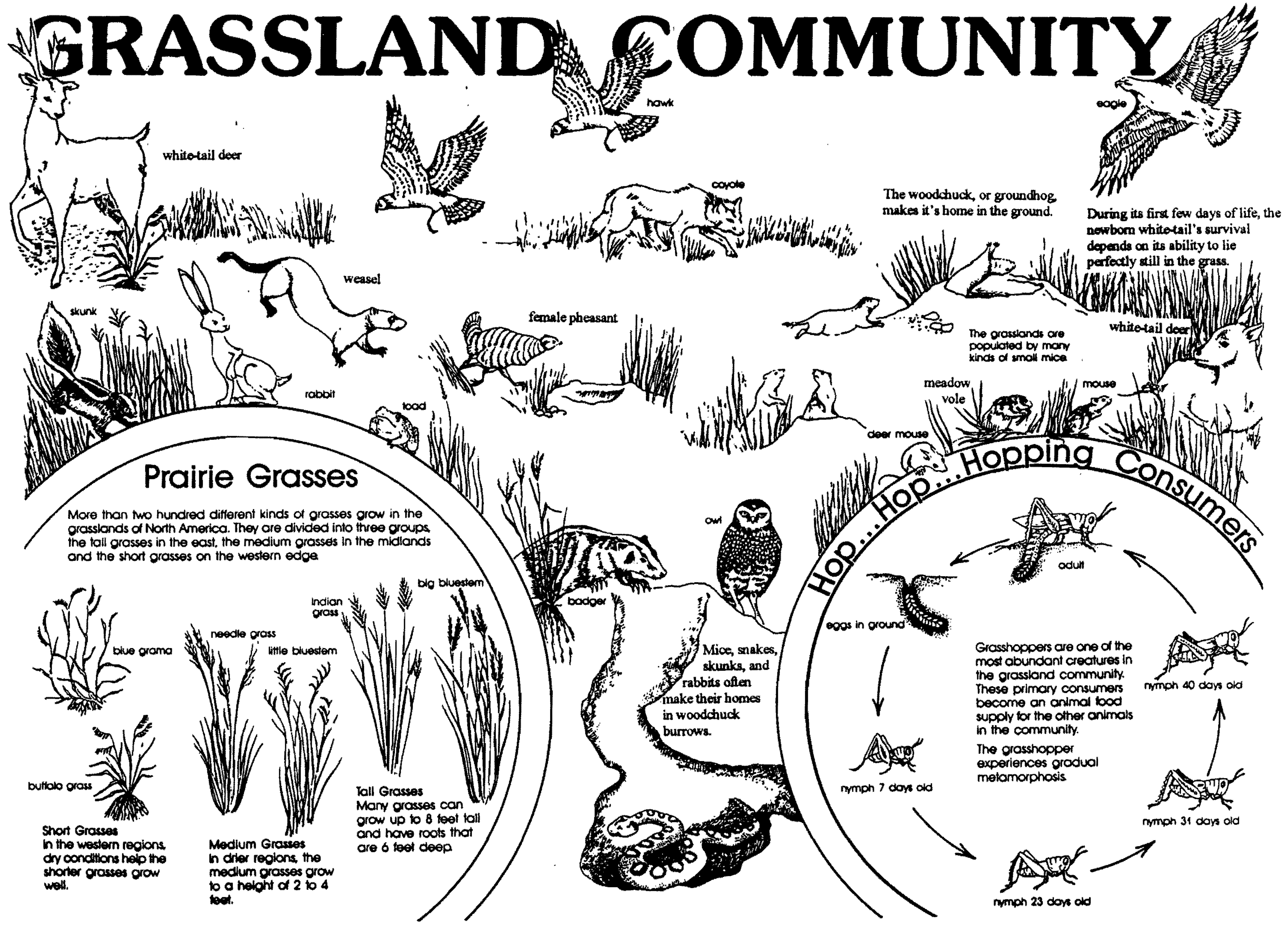
2. Use the strategies for the nature walk when taking any field trip to areas where real animals can be observed.

Evaluation

Name five animals that might be found in each of the following areas: forest, desert, plains, stream, pond, ocean, seashore, park. (Note to Teacher: Please select two areas common to your state.)

Two scientists went to separate parts of the world and studied the animals there. They made these graphs to show the kinds and numbers of animals they found. Do you think they were studying places which were similar or different? Why?





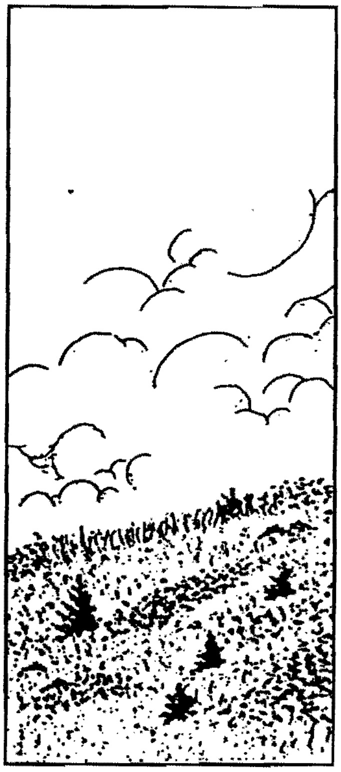
GRASSLAND COMMUNITY
white-tail deer
hawk
eagle
coyote
The woodchuck, or groundhog, makes it's home in the ground.
During its first few days of life, the newborn white-tail's survival depends on its ability to lie perfectly still in the grass.
weasel
skunk
female pheasant
white-tail deer
The grasslands are populated by many kinds of small mice.
rabbit
toad
meadow vole
mouse
deer mouse
Prairie Grasses
More than two hundred different kinds of grasses grow in the grasslands of North America. They are divided into three groups, the tall grasses in the east, the medium grasses in the midlands and the short grasses on the western edge.
big bluestem
indian grass
needle grass
little bluestem
blue grama
buffalo grass
Short Grasses
In the western regions, dry conditions help the shorter grasses grow well.
Medium Grasses
In drier regions, the medium grasses grow to a height of 2 to 4 feet.
Tall Grasses
Many grasses can grow up to 8 feet tall and have roots that are 6 feet deep.
owl
badger
Mice, snakes, skunks, and rabbits often make their homes in woodchuck burrows.
Hop...Hop...Hopping Consumers
adult
eggs in ground
Grasshoppers are one of the most abundant creatures in the grassland community. These primary consumers become an animal food supply for the other animals in the community.
The grasshopper experiences gradual metamorphosis.
nymph 40 days old
nymph 7 days old
nymph 31 days old
nymph 23 days old

From Field to Forest

Name ____________________

Through a series of changes, an abandoned farmer's field can develop into a climax forest. These changes take an orderly pattern as each new plant or animal population makes environmental changes for the new plants and animals that will succeed them. This series of orderly changes is called succession.

Read the description of each step of the succession of an abandoned farmer's field in the Southeastern United States.



Farmer's Abandoned Field

Ten years after Farmer Brown quit working his farm, small pine seedlings began to grow in the abandoned field along with low-growing shrubs, grasses and herbs.

List some animals that would live in this habitat.

____

____

____

Pine Forest

Twenty-five years have passed and the pines have grown tall and mature. Young oak trees start to grow beneath the pines.

List some animals that would live in this habitat.

____

____

____

____

Oak-Pine Forest

The oak trees reach for the sun between the old pine trees. Many older pines die, and young oaks begin to replace the pines.

List some animals that would live in this habitat.

____

____

____

____

Oak Climax Forest

The large oaks dominate the forest. Young oaks grow in the understory, while young pines cannot grow in the shade of the oaks.

List some animals that would live in this habitat.

____

____

____

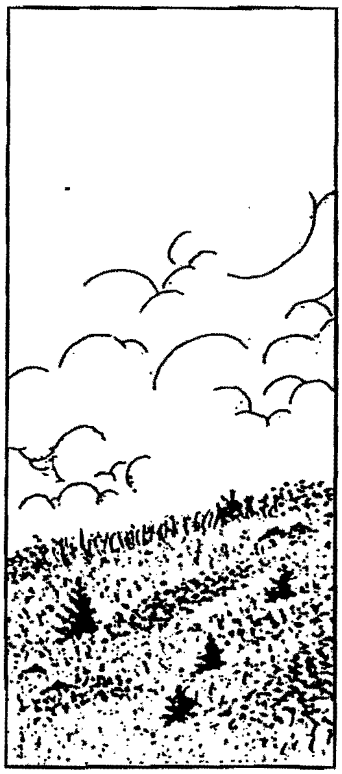
____

From Field to Forest

Name KEY

Through a series of changes, an abandoned farmer's field can develop into a climax forest. These changes take an orderly pattern as each new plant or animal population makes environmental changes for the new plants and animals that will succeed them. This series of orderly changes is called succession.

Read the description of each step of the succession of an abandoned farmer's field in the Southeastern United States.



Farmer's Abandoned Field

Ten years after Farmer Brown quit working his farm, small pine seedlings began to grow in the abandoned field along with low-growing shrubs, grasses and herbs.

List some animals that would live in this habitat.

mice hawks

rabbits

snakes

ground hogs

Pine Forest

Twenty-five years have passed and the pines have grown tall and mature. Young oak trees start to grow beneath the pines.

List some animals that would live in this habitat.

deer

woodpeckers

chipmunks

Oak-Pine Forest

The oak trees reach for the sun between the old pine trees. Many older pines die, and young oaks begin to replace the pines.

List some animals that would live in this habitat.

squirrels

raccoon

fox

Oak Climax Forest

The large oaks dominate the forest. Young oaks grow in the understory, while young pines cannot grow in the shade of the oaks.

List some animals that would live in this habitat.

turkey

grouse

squirrel

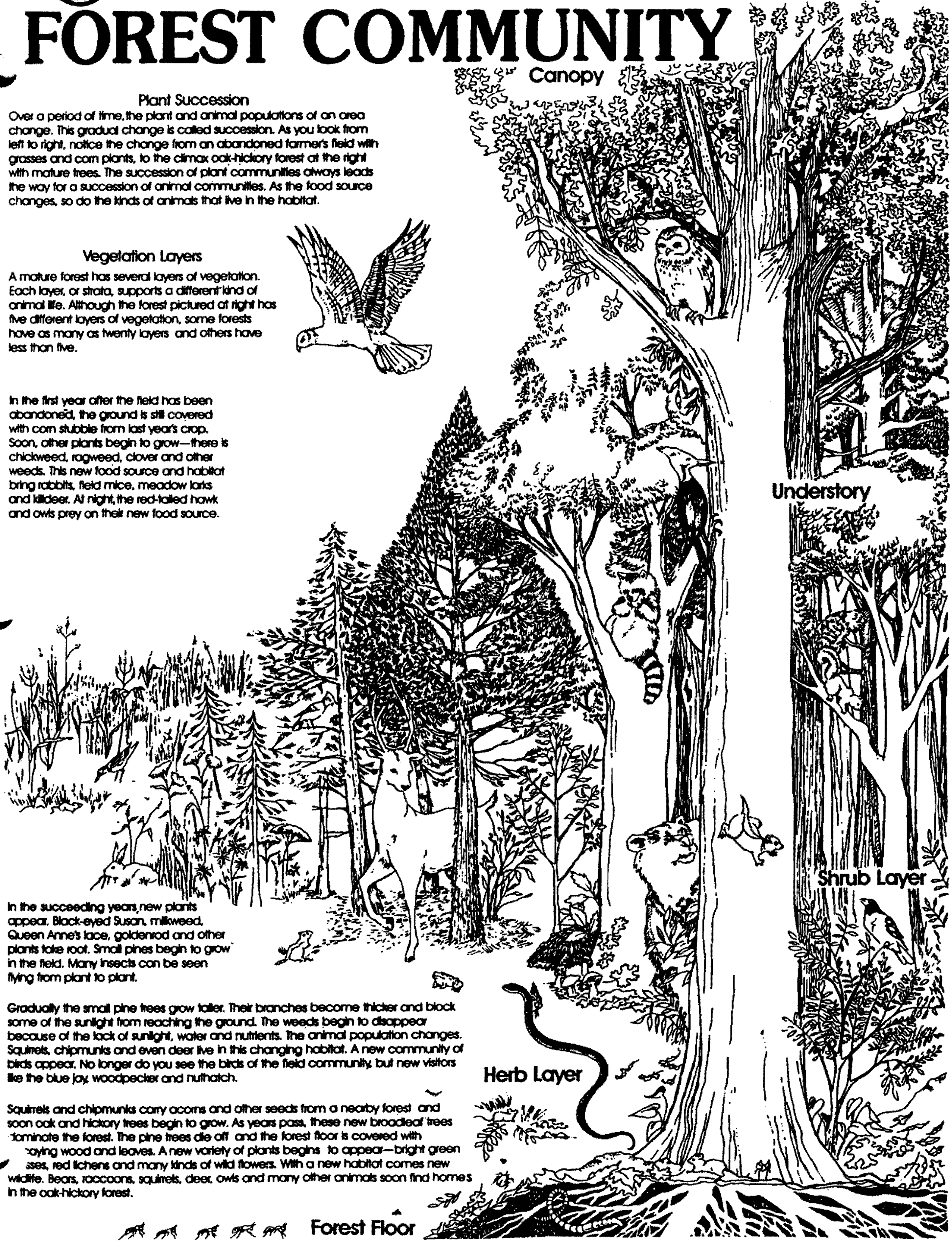
FOREST COMMUNITY

Plant Succession

Over a period of time, the plant and animal populations of an area change. This gradual change is called succession. As you look from left to right, notice the change from an abandoned farmer's field with grasses and corn plants, to the climax oak-hickory forest at the right with mature trees. The succession of plant communities always leads the way for a succession of animal communities. As the food source changes, so do the kinds of animals that live in the habitat.

Vegetation Layers

A mature forest has several layers of vegetation. Each layer, or strata, supports a different kind of animal life. Although the forest pictured at right has five different layers of vegetation, some forests have as many as twenty layers and others have less than five.



In the first year after the field has been abandoned, the ground is still covered with corn stubble from last year's crop. Soon, other plants begin to grow—there is chickweed, ragweed, clover and other weeds. This new food source and habitat bring rabbits, field mice, meadow larks and killdeer. At night, the red-tailed hawk and owls prey on their new food source.

In the succeeding years, new plants appear. Black-eyed Susan, milkweed, Queen Anne's lace, goldenrod and other plants take root. Small pines begin to grow in the field. Many insects can be seen flying from plant to plant.

Gradually the small pine trees grow taller. Their branches become thicker and block some of the sunlight from reaching the ground. The weeds begin to disappear because of the lack of sunlight, water and nutrients. The animal population changes. Squirrels, chipmunks and even deer live in this changing habitat. A new community of birds appear. No longer do you see the birds of the field community, but new visitors like the blue jay, woodpecker and nuthatch.

Squirrels and chipmunks carry acorns and other seeds from a nearby forest and soon oak and hickory trees begin to grow. As years pass, these new broadleaf trees dominate the forest. The pine trees die off and the forest floor is covered with decaying wood and leaves. A new variety of plants begins to appear—bright green grasses, red lichens and many kinds of wild flowers. With a new habitat comes new wildlife. Bears, raccoons, squirrels, deer, owls and many other animals soon find homes in the oak-hickory forest.

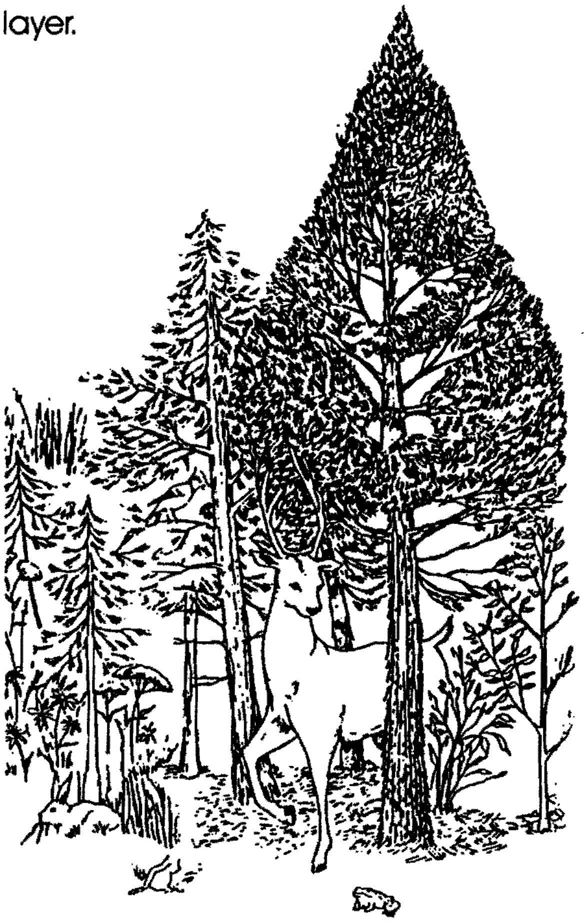
Forest View Apartments

Name ____________________

There are many different habitats within a forest. A typical forest may have several layers of vegetation, much like different floors of an apartment building. Each layer will support different kinds of animal life. A northern hardwood forest may have as many as five layers. The topmost layer, called the canopy, is at the very top of the trees. This may be as high as 150 feet or more from the forest floor. Beneath this is the understory, then the shrub layer, the herb layer and finally the forest floor.

(1) Label the names of the different vegetation layers.

(2) Locate the different kinds of animal life on the poster. Then, write their names on the layer of the vegetation where they would most commonly be found. Many animals can be found on more than one layer.



____________ layer

____________ layer

____________ layer

____________ layer

____________ layer

Forest View Apartments

Name KEY

There are many different habitats within a forest. A typical forest may have several layers of vegetation, much like different floors of an apartment building. Each layer will support different kinds of animal life. A northern hardwood forest may have as many as five layers. The topmost layer, called the canopy, is at the very top of the trees. This may be as high as 150 feet or more from the forest floor. Beneath this is the understory, then the shrub layer, the herb layer and finally the forest floor.

(1) Label the names of the different vegetation layers.

(2) Locate the different kinds of animal life on the poster. Then, write their names on the layer of the vegetation where they would most commonly be found. Many animals can be found on more than one layer.

Canopy layer
eagles
owls
squirrels
insects

Understory layer
woodpeckers
raccoons
insects
flying squirrels

Shrub layer
chipmunks
bear
deer
birds

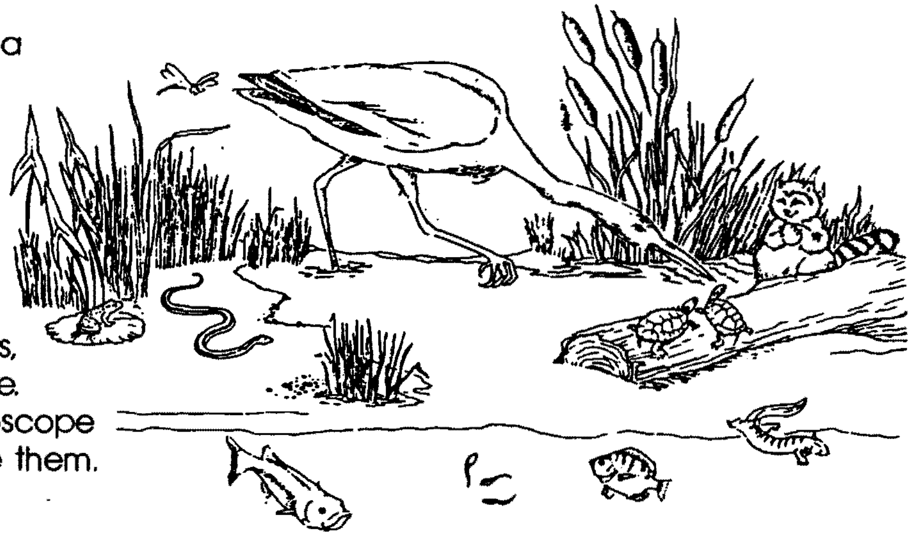
Herb layer
snakes
mice
toads

Forest Floor layer
insects
earthworms

Living Together

Name ______________________

A pond is an important habitat for a variety of different kinds of animals. Many of these animals make their residence in or around the pond while others visit the pond to find food and water. Many of these animals can be easily seen in or around the pond. Others, such as the different kinds of aquatic insects, are very small and difficult to locate. Still others are so small that a microscope is needed to discover and examine them.



Locate as many different kinds of animals that can be found in the pond community. List them in the correct category.

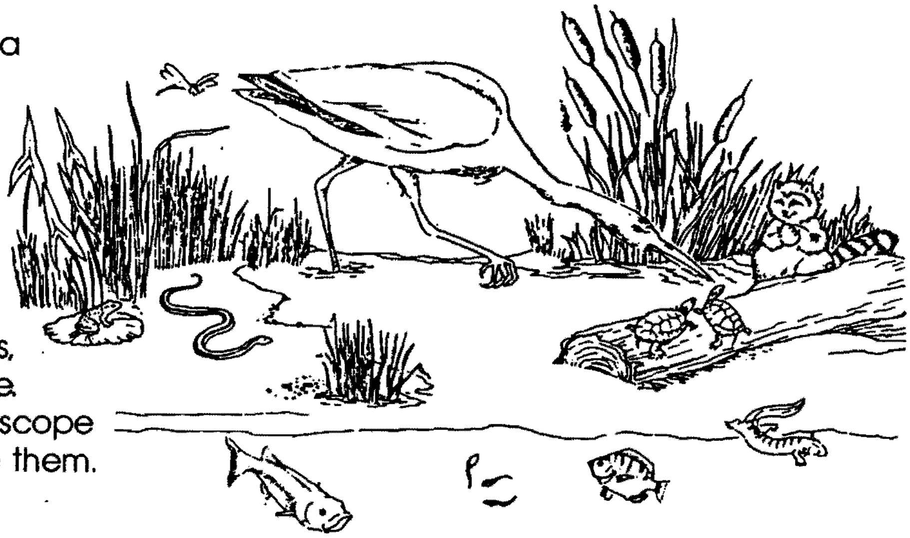
VERTEBRATES				
MAMMALS	**BIRDS**	**AMPHIBIANS**	**REPTILES**	**FISH**

INVERTEBRATES		
INSECTS	**AQUATIC INSECTS**	**OTHER INVERTEBRATES**

Living Together

Name KEY

A pond is an important habitat for a variety of different kinds of animals. Many of these animals make their residence in or around the pond while others visit the pond to find food and water. Many of these animals can be easily seen in or around the pond. Others, such as the different kinds of aquatic insects, are very small and difficult to locate. Still others are so small that a microscope is needed to discover and examine them.



Locate as many different kinds of animals that can be found in the pond community. List them in the correct category.

VERTEBRATES				
MAMMALS	**BIRDS**	**AMPHIBIANS**	**REPTILES**	**FISH**
raccoon	mallard	green frog	garter snake	bluegill
beaver	blue heron	Amer. toad	water snake	sunfish
muskrat	Canada goose	salamander	painted turtle	bass
		bull frog	snapping turtle	crappie
				catfish

INVERTEBRATES		
INSECTS	**AQUATIC INSECTS**	**OTHER INVERTEBRATES**
mosquito	water strider	snails
dragon fly	water boatman	crayfish
damselfly	backswimmer	clams
	insect larve	

Habitat Study

activities with habitats

An intensive study of the components and interrelationships of a particular habitat, combined with comparative studies of neighboring habitats, leads to an understanding of the ecology of the area and ecological principles in general.

habitat explorations

Materials: Recording sheets, clipboards, thermometers, trowels, thread, metal rods, plastic bags, pencils, piece of string about one yard (or one meter) long, masking tape, felt-tipped pens, roll of large paper suitable for making large charts.

Procedure: Prepare your own recording sheets. The following three pages provide examples of the types of information to include in your habitat study. Locate an area that includes several different habitats, such as open field, edge of woods, deciduous woods, small stream, evergreen woods. Divide the children into pairs. Assign each pair a habitat, or, depending on the number of pairs, assign some pairs areas midway between two different habitats. Mark each pair's study area with a circle two yards (or two meters) in diameter, using the string as a compass. (Indicate the boundaries with twigs, pebbles, or by scratching the ground surface with a stick.) Give each pair the first eight materials listed above and have them conduct the experiment and observations of their study area as indicated on the recording sheets. When finished, have each pair bring with them their sheets, collections of signs of animals, plant samples, and soil sample.

Move indoors and give each pair a large piece of paper for making a chart. Have the masking tape, pens, and scissors ready. Have each pair write their type of habitat at the top of the chart and record all the data gathered, as well as tape to the chart the plastic bags with the soil and plant samples and the signs of animals.

Generally, children in the sixth through ninth grades can do the experiments and the collecting in their study areas independently, although the leader should be free to visit the groups to help and encourage. The chart-making usually becomes an engrossing and creative activity. This habitat study requires little or no prior knowledge of natural history on the part of children or leader. It is truly a learn-it-yourself activity.

Without any need to use the term *ecology*, ecological principles become clearer when the data and materials of the charts are compared. Questions arise about why different plants were found in the different habitats, and why signs of certain animals were found in some habitats, but not others. What interrelationships might exist between the plants and animals? How do they correlate with the effects of soil moisture and compactness, temperature, and wind on the habitat?

I know of a teacher who did this habitat study with a class in the fall, and then used the material on the charts with the class for the rest of the school year. There are many follow-up possibilities. For instance, identify the plants and animals of the habitats. Find out the food needs of the animals; which ones depend on the plants, which are predators, and which are the prey? Relating the animals in this way demonstrates a food chain of the area. Make graphs of the comparative data found in the habitats. Use the factual data for bases for problems in arithmetic. Research how the Indians might have used the habitat. What evidences of modern people were found in the habitats? Draw items found there. Make dioramas of the habitats.

This habitat study can be varied easily. Younger children who cannot do the work independently enjoy doing it as a group. A whole group studies a habitat together with a leader and afterward makes the chart together. Other groups do other habitats, so that there are different charts for comparisons. The studies can be made more sophisticated: use light meters to determine amounts of sunlight; set out rain gauges to measure rainfall over a period of time; use litmus paper to determine the soil's acidity or alkalinity. Return to the habitats during different seasons and repeat the studies.

habitat study

temperature

Put the thermometer in each position listed below for about a minute. Read each temperature and record it below.

______ At shoulder height (hold thermometer carefully; keep your fingers off the bulb)
______ At the surface of the ground
______ Below the ground (use a trowel to dig a small hole about the depth of the trowel blade; put the thermometer into it)

soil moisture

Use the trowel to dig up a small amount of soil. Feel it in your hands and record below how it feels.

______ Dry (falls apart and sifts through your fingers)
______ Slightly moist (looks moist but does not stick together when squeezed)
______ Moist (clumps together when squeezed)
______ Very moist (feels wet when squeezed)
______ Wet (water drips out when soil is squeezed)

soil sample

Dig a small sample of soil and put it into a plastic bag.

soil compactness

Take the metal rod and push it into the soil in several different places. How easy or difficult is it to push the metal rod into the soil? Check the best description below.

______ Very easy (like pushing into soft ice cream)
______ Easy (like pushing into a snowball)
______ Hard (like pushing into modeling clay)
______ Very hard (so hard that you almost cannot push the rod in)

wind speed

Hold a piece of thread at arm's length and pretend that it is the arm of a clock. If it hangs vertically, it is at six o'clock and there is no wind. Record below whether the thread stayed at six o'clock, or moved to seven, or eight, or nine o'clock.

______ Holding thread over your head
______ Holding thread at your waist
______ Holding thread down near the ground

animal life

1. Collect signs of animals or animal activity (for example, feathers, nibbled-on acorns) and put each one into a plastic bag. Don't forget to include any signs of human activity, too.

2. Describe below any signs of animal activity that cannot be collected (for example, footprints, burrows).

3. Identify, describe, or sketch below any live creatures found on or in your plot.

live creatures

plant life

Bring sample leaves back with you for use on the chart, if you wish.

How many trees are in the area? ______
Identify them if you can. Describe them and draw a leaf from each one.

How many bushes are in the area? ______
Identify them, if you can. Describe them and draw a leaf from each one.

How many different varieties of other plants are in the area? ______
Identify, if you can, the five most common ones. Also, describe them and draw a leaf of each one.

Pollution Pursuits

Answer some pollution survey questions and play a pollution trivia game.

Objectives:
Discuss the connection between individual behavior and pollution. Describe several types of pollution and explain what causes each type. Explain how pollution affects people, wildlife, and the environment.

Ages:
Intermediate and Advanced

Materials:
- ***copies of the survey questions on page 10***
- ***trivia questions on pages 10-11***
- ***slips of paper***
- ***chalkboard or easel paper***
- ***index cards cut into 3-inch squares***
- ***sack***
- ***drawing paper or mural paper***
- ***crayons or markers***
- ***tape***

Subjects:
Science and Social Studies

Here's an activity that you can use to kick off *and* wrap up a unit on pollution. In Part 1 you can find out what your kids know and think about pollution by having them take a short survey. Then, by playing a trivia game in Part 2, the kids can review what they've learned.

PART 1: THE SURVEY

Pass out a copy of the survey questions under "What Do You Think?" on page 10 to each person. Tell the group that the questions deal with different aspects of pollution, and that you'd like them to answer the questions as honestly as possible. Explain that you want to find out what they know and think about pollution, but reassure them that it's not a test. (Some of the questions are more difficult than others. Adapt them to fit the needs of your group.)

After the kids have completed the survey, collect their answers and the questions. Explain that they'll get a chance to discuss the answers later on. You can use the kids' answers to help you decide what to cover during your pollution study.

After completing your pollution studies, pass out the survey questions and have the kids answer them again. Then pass out their original responses and have the kids compare their answers. Ask them how their answers changed, if at all. Then discuss why they think their answers changed.

PART 2: WHAT'S YOUR POLLUTION IQ?

Your kids can play a team game that will help them review—and tie together—all they've learned about pollution. Here's how to set up and play the game:

Getting Ready

1. Write the numbers 1-52 on separate slips of paper and put the slips in a sack. Also include five slips with an "X" marked on each one and five slips with an "O" marked on each one.

2. Divide the group into three teams and give each team a sheet of drawing paper or mural paper and some crayons or markers. Assign one team to be air pollution, one to be water pollution, and one to be land pollution. Explain that, as a group, each team should draw a scene that is affected by the type of pollution they've been assigned. Tell them to make their drawings as detailed as they'd like and at least 11" X 17".

3. Copy the following list of pollutants on a chalkboard or sheet of easel paper. Have each team make two sets of pollutant cards by copying each of the pollutants listed under each team's name onto two separate 3-inch square cards. (There should be a total of 12 pollutant squares for each team.) Then have the kids on each team "pollute" their scene by taping the 12 pollutants on their drawing.

AIR: carbon dioxide, acid rain, CFCs, smog, particulates, carbon monoxide
WATER: lead, mercury, PCBs, animal waste, fertilizers, pesticides
LAND: radioactive waste, plastic, toxic ash, paper, metal, yard waste

4. Have each team pick a captain. Then have the teams hang their drawings where everyone can see them.

Playing the Game

Tell the kids that the object of the game is to get rid of all 12 pollutants from their scene. To do that, they'll have to correctly answer pollution questions. To play, have a person from the first team draw one of the numbered slips of paper from the sack. Then read the corresponding question listed under "Pollution Puzzlers" below. Only the team captain can answer, but he or she should confer with the rest of the team before giving an answer.

If team members answer the question correctly, they get to remove one or more of the pollutants from their scene. (Some of the questions indicate that a team can remove two pollutants.) If they answer incorrectly, the numbered slip of paper goes back in the sack. After one team has a turn, it's time for another team to pick a question and answer it. If team members pick a slip with an X, they have to put one pollutant back on their drawing (if they've lost one) and they don't get to answer a question. But if they pick a slip with an O, they get to take a pollutant off their drawing and then pick another question. You can play until one team has removed all 12 pollutants, or you can set a time limit and declare a winner when the time is up.

What Do You Think?

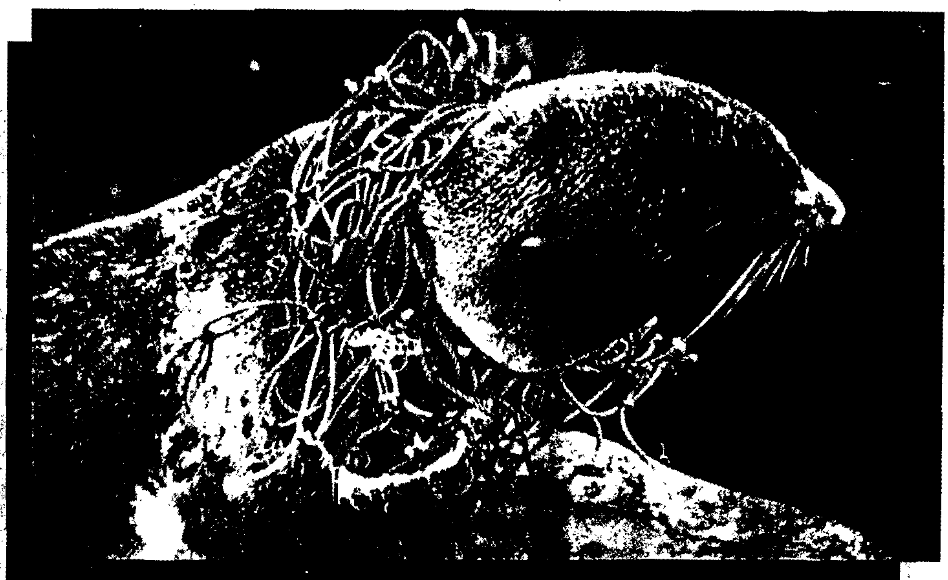
1. What is pollution? List five examples of pollution.
2. List some of the causes of pollution.
3. How do you contribute to pollution? Name three ways.
4. What are three things you could do to help reduce pollution?
5. Give some examples of how pollution affects living things and the environment.
6. Can pollution in one country harm people in another country? Explain your answer.
7. Do you think the United States creates more pollution than other countries? Explain your answer.

Pollution Puzzlers

1. Which of the following is an example of pollution? Give all correct answers. (all)
a. litter in a stream
b. noise from a nearby airport
c. cigarette smoke in a restaurant
d. a billboard
e. fishing line tangled around a log
2. Name three major pollution events that have occurred in the last decade. (*Exxon Valdez* oil spill; Chernobyl nuclear power plant explosion; *Mobro* garbage barge, and so on)
3. How does the world's increasing human population contribute to pollution problems? (more people means more hazardous materials; more garbage; more energy use, which contributes to pollution; and so on)
4. Give an example of noise pollution and explain how it can hurt people and other living things. (construction noise, noise from jets and motor vehicles, noise from stereos, and so on; can damage people's hearing, can disturb wildlife breeding and feeding activities)
5. Which pesticide caused a decrease in bald eagle populations following World War II? (DDT)
6. What is the connection between plastic foam and the ozone layer? (Some foam is made with CFCs, which deplete the ozone layer.)
7. True or false: Plants can help absorb indoor air pollution. (true)
8. What are fossil fuels? (coal, oil, and other fuels that formed millions of years ago from the remains of ancient plants and animals)
9. True or false: Air pollution inside buildings can sometimes be worse than air pollution outside. (true)
10. Name three things that contribute to indoor air pollution. (cigarette smoke; emissions from copy machines, art supplies, new carpeting and furniture; and so on)
11. Name two possible consequences of global climate change. (sea level rise, droughts, cooling or warming in some areas, extinction of some species of plants and animals)
12. What air pollutant is the main contributor to the greenhouse effect? (carbon dioxide)
13. [worth two pollutants] Name two ways that low-level ozone can affect people or the environment. (makes people's eyes and throats burn, damages crops and forests, makes rubber and other materials deteriorate faster than they normally would)
14. How does acid rain form? (pollutants released from power plants and motor vehicles combine with water droplets in the atmosphere and fall to earth as acid rain, fog, or snow)
15. Why is it important to protect the ozone layer? (to keep the amount of harmful ultraviolet radiation that reaches the earth from increasing, which would increase occurrences of skin cancer and affect plant growth)
16. How can deforestation contribute to global climate change? (the burning of forests releases more carbon dioxide into the air and also removes trees and other vegetation that would otherwise absorb carbon dioxide)
17. [worth two pollutants] Name three products that contain CFCs. (some aerosols, computer parts, coolants for refrigerators and air conditioners, many kinds of foam products)
18. How can cutting down on energy use help reduce air pollution? (reduced demand for electricity results in less coal or oil being burned in power plants, which results in less air pollution)
19. True or false: Air pollution is something you can always either see or smell. (false)
20. What is groundwater? (underground water that fills the spaces between soil particles and rocks)
21. What are some of the ways groundwater gets polluted? (leaking landfills, leaking hazardous waste sites, pesticides and other chemicals seeping through the soil, and so on)

22. The area of land that rain and snowmelt drain off of is called a ______. (watershed)
23. Toxic chemicals gushing out of a pipe into a river is an example of what kind of pollution: nonpoint or point pollution? (point pollution)
24. Pesticides, oil, and fertilizers washing into rivers from roads, fields, and farms is an example of what kind of pollution: nonpoint or point pollution? (nonpoint pollution)
25. More ocean oil pollution comes from: (b)
a. large oil tanker spills
b. routine cleaning of empty oil tankers
26. [worth two pollutants] Name four substances that can contaminate groundwater. (pesticides, road salt, motor oil, fertilizers, animal waste, gasoline, battery acids, and so on)
27. True or false: Wetlands can help purify water by absorbing harmful pollutants. (true)
28. Name two ways that plastic trash can harm wildlife. (when eaten, can block digestive system and cause starvation; can entangle or strangle birds and other animals)
29. What ingredient in laundry detergent can cause algae to grow much faster than normal? (phosphate)
30. What is sludge? (solid waste from sewage treatment plants)
31. What annually uses the most water in homes: dishwashers, toilets, or bathtubs? (toilets)
32. Name three things that can contaminate lakes, streams, rivers, and oceans. (pesticides, fertilizers, trash, human sewage, agricultural waste, industrial chemicals, acid rain, dirt and other sediment, oil and gasoline, and so on)
33. Name a product in your house or garage that can cause water pollution. (cleaners, silver polish, pesticides, paint thinner, motor oil, laundry detergent, and so on)
34. Name four garbage items that can be recycled. (glass bottles, plastic soda bottles, branches and leaves, motor oil, and so on)
35. What does a resource recovery plant do? (sorts trash and recovers the metals, paper, and other valuable materials, and then burns the remaining trash to produce energy)
36. Give three examples of hazardous waste. (pesticides, oil, paint thinner, acids, explosives, radioactive waste, and so on)
37. How do we currently dispose of more than 75 percent of our trash? (by dumping it in landfills)
38. What is *integrated waste managment?* (waste disposal system that makes use of recycling, source reduction, incineration, and landfilling)
39. Name several types of farm waste that contribute to pollution problems. (manure, crop residues, pesticides, fertilizers, and so on)
40. Define *biodegradable*. (having the ability to be broken down into simpler substances by bacteria and other organisms)
41. What are three ways that plastic contributes to global pollution problems? (made from oil, which if spilled during transport can pollute water; manufacturing process creates air pollution; plastic litter can strangle or entangle wildlife; adds to solid waste problem)
42. How does recycling save energy and resources? (eliminates need to extract and process more raw materials, which depletes natural resources and uses more energy)
43. [worth two pollutants] Name three ways cars contribute to air, land, and water pollution. (see page 8)
44. Name three ways people can reduce pollution caused by cars. (carpool, walk, bike, or use public transportation; recycle used motor oil; keep cars tuned up for better fuel efficiency; recycle air-conditioning coolant; and so on)
45. How can dirt and other sediment harm aquatic animals and plants when it washes into lakes, rivers, and streams? (smothers bottom-dwelling organisms; clogs fish gills; keeps sunlight from reaching aquatic plants; decreases visibility, making it harder for some animals to find food; and so on)
46. Explain why biodegradable materials don't break down in landfills. (lack of water and oxygen prevents bacteria and other organisms from breaking down landfill materials)
47. What are three ways that communities can help reduce pollution? (set up recycling programs, provide public transportation, sponsor hazardous waste pickup days, and so on)
48. [worth two pollutants] Name a national law that was passed to help reduce pollution. (see page 83)
49. [worth two pollutants] Give an example of a technology that causes pollution problems *and* an example of a technology that cuts down on pollution problems. (causes problems—cars, power plants, plastic, and so on; solves problems—smokestack scrubbers, catalytic converters, biodegradable plastics, and so on)
50. Name two energy sources that create minimal pollution. (solar, wind, and geothermal power)
51. Name three ways that consumers can help cut pollution. (buy products in recycled and recyclable packaging; buy in bulk; don't buy overpackaged goods, toxic products, and disposable items; write to companies; and so on)
52. Name two ways that acid rain affects the environment. (speeds up the erosion of buildings and statues; can kill some fish and other aquatic animals and can harm their eggs and young; may make trees more susceptible to disease, cold, and insect attack)

USDA—Soil Conservation Service



Creative Dramatics / Cooperative Learning continued

A Community Alphabet

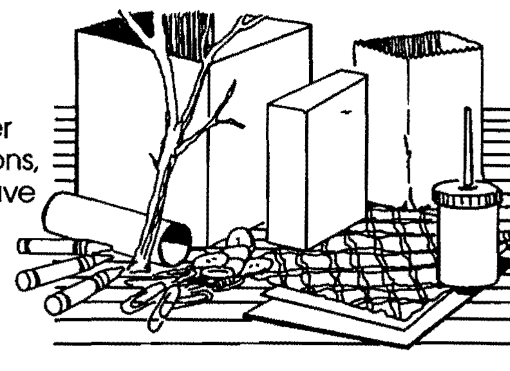
Assign each of 4 groups a community. After each letter of the alphabet, they are to write 2 words that are somehow connected to their community. They can do nouns or adjectives. They will have to do some research.

Pond Community

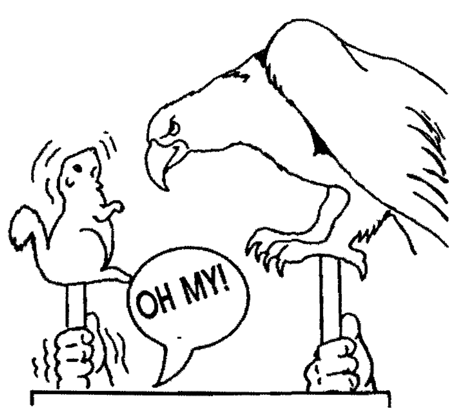
A arrowhead
active
B beetles
bass
C cattails
common garter snake

Art Projects

Cardboard Communities



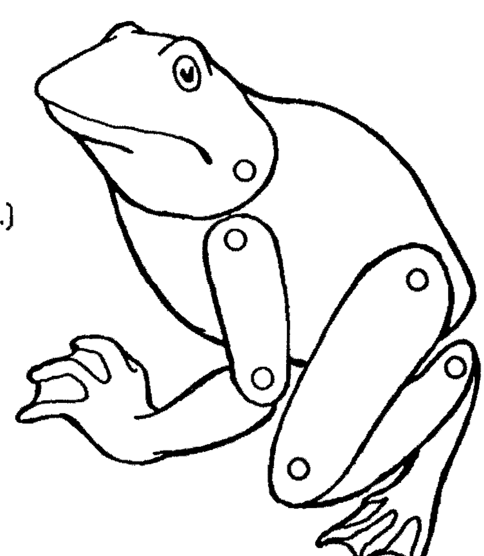
- Assign each group a community.
- Provide students with large cardboard boxes and many other materials (snack and cereal boxes, fabric, buttons, egg cartons, construction paper, twigs, paper clips, markers, glue, etc.). Have them create their own community.
- Have each group write a report to go with their community.
- These would be great to display at an Open House or at Parent/Teacher conferences.



It's Show Time!

- Have each student make animal puppets. Provide them with all kinds of materials (don't forget tongue depressors) to use for their puppets.
- Group students according to the communities to which their puppets belong. (You could do this by making a graph on the chalkboard.)
- Have students write and perform skits using their puppets. The skits could be done community by community, or you could have the puppets all mixed together.

Giant Jumping Jacks



- Students will love making these giant animals.
- Provide students with newsprint, tagboard, brads, construction paper, glue, scissors, markers, string, hole punch, etc.
- Have each student design an animal found in one of the communities in nature. (Or, you could provide them with patterns.)
- Students should make each body part separate: head, body, upper arms, lower arms and hands, upper legs, lower legs and feet. Have them draw it first on newsprint and then on tagboard.
- Have them decorate their animals and attach the body parts to each other with brads.
- Have students perform skits with their Giant Jumping Jacks.

Compound Characters

Many creatures found in nature have names that are compound words. Have students choose 4 and draw the literal translation of their names on a paper folded into 4 sections.

Leaves and Trees

Objectives:

- Discuss how trees have adapted to their environments
- Organize a set of objects with shared characteristics
- Use a simple scientific key to determine the type of tree
- Take measurements and conduct counts of trees
- Identify and compare measurements of trees
- Organize data gathered into graphs and charts
- Discuss how the forest is affected by humans

What to Teach	Teaching Suggestions
Teacher background.	- Background information: "What Makes a Tree a Tree?"
Q: What is a tree?	- Question students as to what makes a tree a tree. Are trees plants? Where do trees grow? What are trees used for by humans? How are trees used by animals? Are there different types of trees?
Introduce students to "their" tree to help answer the questions above.	- Follow the suggested guidelines under "Get to Know a Tree!" Have students adopt trees in the school yard and keep a journal of their observations for the duration of the lesson.
Q: Were any of your trees different from each other? Q: Are there different types of trees? Name some.	- Some students should have adopted pine trees, others should have broad-leaved trees.
Discuss with students the different types of trees (ie. deciduous versus evergreen or coniferous).	- Any place that sells lumber could provide you with samples of different woods. By showing examples of deciduous and evergreen leaves and wood, have students come up with a list of differences between the two.

What to Teach	Teaching Suggestions
	Deciduous- lose leaves every year - are bare in the winter - have mostly broad leaves - usually have hard wood Evergreen- green all year round - leaves are gradually replaced at different times of the year - most leaves are "needles" - usually have softer, lighter wood
Question students as to what are the parts of a tree. Most students will probably answer bark, leaves, and roots.	-Q: Do trees have other parts? How do they get water up to their leaves? -Q: Maple syrup is made from trees. Where is this part?
Label the parts of a tree.	- Have a cross-section of an actual log or stump. On it, label the different parts, referring to "Parts of a Log" - Have students visualize the parts and functions of a tree through the activity "Build a Tree."
Observe and organize leaves into like categories.	- Have students do the activity titled "Learning About Trees." - Tree types can be distinguished by leaf shape, branching, tree shape, and bark.
Student activity.	- Have the students collect and preserve leaves they matched in the above activity in wax paper or contact paper as classroom decoration.
How do we determine what type a tree is? (And why is it important to know what type of tree it is?)	-Q: (referring back to the "Learning About Trees" activity) How did we separate the leaves into groups? -Q: What can we look at to tell trees apart? - leaf shape - branching - bark - fruit

What to Teach	Teaching Suggestions
Introduce common leaf terms.	- Refer to the "Keying Out Trees" leaf key for the terms alternate, opposite, simple, compound, toothed, lobed, and margin. - Background information: "Leaf Characteristics."
Discuss the concept of a leaf key and what it does to help us determine tree type.	- A "key" is like a maze, also, it is a set of questions where the answer is one or two and leads to the end answer. It's a process of elimination. - Demonstrate the concept of keying out an object using the activity "Keying Out Trees" by first keying out the students and then by keying out the leaf pictures.
Practice keying out the trees in the school yard.	- Depending on how students grasp the scientific keying concept, "Learning to Know Trees" is a simple key that teachers or students can use. It also includes pictures and information about common Ohio trees. - Students can also try to use the "A-Mazed By Trees" key for a different style of key. - Either way, have students key out the trees in the school yard in groups or have the class help you key out a few trees to see how it's done (the other keys have been provided for your information).
Visit to Sharon woods Metro Park.	**- The naturalist will introduce students to the wet woods at Sharon Woods. The importance of trees to people and wildlife will be discussed. The use of a scientific key as well as the measurement of trees will be introduced.**

What to Teach	Teaching Suggestions
Discussion	- Have a classroom discussion on what was learned and observed at Sharon Woods. How have people and animals played a role in shaping the forest that is there now?
Measure trees around the school yard to find the largest tree.	- Follow the directions under the activity titled "Tree Champs"
Have students graph the results of their measurements.	- Students can graph their results individually or as a class. From the graphs, have students determine the largest tree measured. Height, circumference, crown spread, and/or total points can be graphed separately or together.

WHAT MAKES A TREE A TREE?

Everyone knows what a tree is. Right? Trees are those tall green things with leafy branches that grow along sidewalks, line city parks, and stand side by side in forests. But wait. Not all trees are tall. Some Arctic spruces, for example, never grow more than a foot (.3 m) tall. And not all trees have leafy branches either. Saguaro cactuses, which are a type of tree, have spines instead of leaves.

SO WHAT IS A TREE?

It's harder to define what a tree is than you might think. Although trees share similar characteristics, there are always exceptions that don't fit a nice, neat definition. But here are some of the main ways that trees differ from other types of plants:

Super-sized Plants: Although there are exceptions, most trees grow much taller than other kinds of plants. For example, you'll never run into a 100-foot (30-m) dandelion. But 100-foot (30-m) trees are very common. Unlike most other plants, trees have woody roots, trunks, and limbs that provide the physical support that allows them to grow so tall (see page 6).

Some scientists use size as a way to help define trees. They say that trees are plants that are 15 to 25 feet (5 to 8 m) tall and have a stem (trunk) that is at least 3 to 4 inches (8 to 10 cm) thick. But many scientists don't include a height or diameter limit since trees that grow in very harsh environments, such as Arctic spruces, are often much smaller than other plants.

Redwood trees in the Pacific Northwest are the tallest living organisms. They can grow more than 350 feet (105 m) tall.

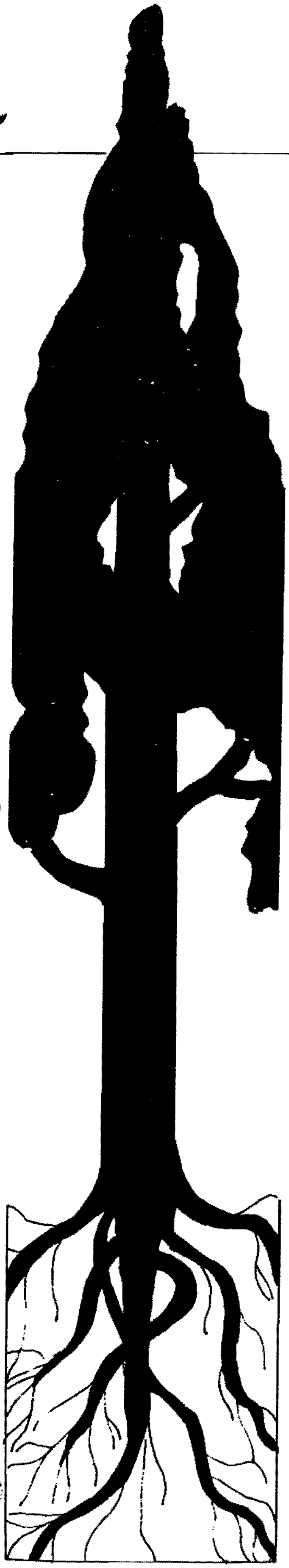
A Trunk That Stands on Its Own Roots: Trees are not only taller than most plants, they are also built in a special way. Most trees have one main woody trunk that supports the entire tree. This makes them different from shrubs or vines. (Shrubs often have many woody stems. Vines often have a woody stem, but the stem can't support the weight of the plant.)

Growing Old Gracefully: Trees live longer than most other plants. In fact, some of the oldest living things on earth are trees. For example, bristlecone pines can live for over 4500 years!

Unlike *annuals* (plants that sprout, reproduce, and die in one season) and *biennials* (plants that sprout, reproduce, and die in two seasons), trees are a type of *perennial.* Perennials live for many seasons. Non-woody perennials, such as lilies and irises, die back each year and pass through the dormant season as underground roots, stems, bulbs, or tubers. But trees don't die back. Many do become dormant during the winter, but the stems, branches, and twigs (as well as the roots) are still alive and will continue to grow taller and thicker each year. And because of their unique "plumbing" (see page 6) and their strong, woody support system, trees can survive much longer than other perennials.

KINDS OF TREES

Trees come in different shapes and sizes, from gnarled old bristlecone pines to prickly saguaro cactuses. Worldwide, there are over 20,000 different species of trees. Over 800 grow in North America.



Trees are classified according to how they reproduce, what types of flowers and seeds they have (if any), how they grow, and how they are structured inside. (Sometimes trees that look very much alike are not closely related.) Most trees fall into these two main plant groups:

Gymnosperms (JIM-no-sperms): Plants that have "naked" seeds, which means the seeds are not enclosed in flowers (and later, fruit). (Gymnosperms do not produce true flowers or fruit.) In most gymnosperms, the seeds are produced on the surface of the scales of female cones. Most gymnosperms are pollinated by the wind.

Conifers are the most common types of gymnosperms. Pines, hemlocks, redwoods, spruces, and firs are all types of conifers. Coniferous trees are also called needle-leaved trees because most have thin, needlelike leaves. There are about 500 species of conifers in the world.

Angiosperms (AN-gee-oh-sperms): Flowering plants. Angiosperms are the only types of plants that have true flowers and bear their seeds in fruits. There are over 235,000 species of angiosperms. Oaks, willows, maples, birches, palms, and all other broad-leaved trees (trees with flat, broad leaves) are in this plant group. So are all the flowering non-trees, such as tulips, blackberries, poppies, and so on.

Note: Some scientists also consider tree ferns to be a type of tree. Tree ferns belong to the fern plant group. The members of this group do not produce seeds, flowers, or fruit. Instead they reproduce by spores. Although some tree ferns get to be over 80 feet (24 m) tall and live for many years, they don't have the same woody structure that most other trees have.

TONS OF TREE TERMS

There are all kinds of general tree terms floating around that can make learning about trees pretty confusing. We've already talked about needle-leaved trees and broad-leaved trees. Here are a few more tree terms that you'll often see:

Hardwoods: Foresters often call broad-leaved trees "hardwoods" because most broad-leaved trees have harder wood than do needle-leaved trees. For example, maples and oaks are known for their tough, hard wood and are often used to make high-quality furniture and floors. But the term hardwood is confusing because some broad-leaved trees, such as cottonwoods and magnolias, have very soft, lightweight wood.

Softwoods: Softwood is another confusing term because not all softwoods are soft. Foresters use the term softwood to describe needle-leaved trees, such as pines, spruces, and redwoods, because most have softer wood than do broad-leaved trees. But some softwoods, such as yellow pines and yews, have very hard wood.

Deciduous and Evergreen Trees: Deciduous trees are trees that lose all of their leaves every year. (In temperate regions most lose their leaves in fall.) Evergreen trees do not lose all their leaves at once. Instead they go through a gradual replacement. Each year they produce some new leaves, but, unlike deciduous trees, they drop only the oldest ones each year. (Most evergreen leaves stay on a tree from 2 to 4 years before dropping.) So instead of being bare in winter, as deciduous trees are in many areas, evergreen trees have leaves year round.

In North America, almost all broad-leaved trees are deciduous, but a few are not. For example, holly trees, live oaks, and palms are broad-leaved trees that do not drop their leaves in fall. (In the tropics, however, most broad-leaved trees don't drop their leaves during one season. Instead they lose their leaves gradually and remain green all year.) Most needle-leaved trees in North America are evergreen. But a few needle-leaved trees, such as larches, are deciduous.

TREE PARTS AND HOW THEY "WORK"

Although there are thousands of different kinds of trees in the world, most trees work in much the same way. Here's a look at how the parts of a tree work together to help a tree get the food, water, and minerals it needs to survive.

The Trunk: The trunk of a tree is important for two reasons: First, it acts as a support rod, giving the tree its shape and strength. Second, it acts as the central "plumbing system" in a tree, forming a network of tubes that carries water and minerals up from the roots to the leaves, and food (sugar) from the leaves down to the branches, trunk, and roots.

The easiest way to see how a tree works is to look at a cross section of the trunk. Here are the five main layers you would see, and what each layer does (see the diagram on page 10):

1. Barking Up the Right Tree: The outer layer of the trunk (and branches) is called the *outer bark* or just the *bark*. Tree bark can be smooth, scaly, rubbery, flaky, craggy, or bumpy. Its texture, thickness, and flexibility depend on the type of tree. Although bark looks different from tree to tree, it serves the same purpose—to protect the tree from injury and disease. Some trees have very thick bark that helps prevent damage from fires. Others have bad-tasting chemicals in their bark that discourage hungry insects. And some bark is covered with spines or thorns that keep browsing mammals away.

The bark of large Douglas firs and sequoias may be more than two feet (.6 m) thick.

2. Food Is for Phloem: The layer next to the outer bark is called the *inner bark* or *phloem* (FLOW-um). The phloem is a thin layer that acts as a food supply line from the leaves to the rest of the tree. Sap (water containing dissolved sugars and nutrients) travels down from the leaves through channels in the phloem to the branches, trunk, and roots, supplying all the living parts of the tree with food. At certain times during the year, the phloem also transports stored sugars up from the roots to the rest of the tree. (If you were to cut a band around the trunk, through the bark and phloem, the tree would probably die. That's because the phloem would be severed and food could no longer flow to the lower trunk and roots.)

3. Keep 'em Coming, Cambium: Next to the phloem is a very thin layer called the *cambium*. (It is often only one or two cells thick, and you need a microscope to see it well.) The cambium is one of the growing layers of the tree, making new cells during the growing season that become part of the phloem, part of the xylem (see below), or more cambium. The cambium is what makes the trunk, branches, and roots grow thicker.

4. Up, Up, and Away with Sapwood: The layer next to the cambium is called the *sapwood* or *new xylem*. The sapwood is made up of the youngest layers of wood. (Each year the cambium adds new layers of woody tissue.) The sapwood is a network of thick-walled cells that forms a pipeline, carrying water and minerals up the tree from the roots to the leaves and other parts of the tree. The sapwood also stores nutrients and transports them across the tree, from one part to another.

5. A Dead Heart: Most of the trunk in an old tree is dead wood called *heartwood* or just plain *wood.* The heartwood is *old xylem* that no longer transports water and minerals up the tree. (After a few years the sapwood in most trees gets filled in with resinlike material and slowly changes into heartwood. The new xylem is the only part of the wood that works as a transport system.) The heartwood is often much darker in color than the sapwood.

The heartwood gives the tree support. But sometimes it rots away, leaving a hollow, living tree. Hollow trees often topple over or split apart in storms because they are very weak after the heartwood has decayed.

Note: Palm trees have a different type of structure than most other trees. They do not have real branches and produce no annual rings. (See page 16 for more about rings.) Instead they grow taller without growing thicker.

The Roots: A tree's roots are long, underground branches that spread out to help anchor the tree and to absorb water and nutrients from the soil. Some trees have long taproots that reach straight down for 15 feet (4.5 m) or more. Other trees have more shallow root systems that lie closer to the surface of the ground.

Large taproots and lateral roots branch into smaller and smaller roots. An average tree has millions of these small rootlets, each covered with thousands of fine *root hairs.* The root hairs make it easier to soak up water and dissolved minerals from the soil. (Most of the rootlets lie very close to the surface of the ground where most of the water and nutrients are located.)

The Leaves: From skinny pine needles to broad palm leaves, all tree leaves serve the same purpose—to make food for the tree. Leaves use carbon dioxide from the air, water from the roots, and the sun's energy (in the form of sunlight), to make sugar (glucose). This food-making chemical reaction is called *photosynthesis.* Photosynthesis can take place only in the presence of *chlorophyll*—the green pigment that is found in all green plants. Chlorophyll absorbs the sunlight needed for photosynthesis. During photosynthesis the leaves release oxygen which becomes part of the air that we and other animals breathe.

Water and Trees: Trees, like all living things, could not survive without water. Here are some of the reasons that water is so important to a tree:

- a large percentage of each living cell in a tree is made up of water
- water helps move dissolved minerals and gases from cell to cell
- water pressure inside a leaf's cells helps maintain the leaf's shape
- water is needed in order for photosynthesis to occur (Water for photosynthesis is carried up through the xylem network from the roots.)
- water carries dissolved sugars (made during photosynthesis) down through the network of phloem to the branches, trunk, and roots

Although trees use a lot of water every day, they also lose a lot of water. About 99% of the water the roots absorb from the soil evaporates from the leaves through a process called *transpiration.* (Water evaporates through tiny pores in the leaf [stomata] as carbon dioxide—also needed for photosynthesis—rushes in. During photosynthesis there is a trade-off between water loss and carbon dioxide gain.) As water evaporates, it pulls up more water from the roots to the leaf. This "transpiration pull" is one of the things that help move water and minerals through the tree and help keep trees cool in hot weather.

Oxygen for Energy: Like almost all living cells, tree cells need oxygen in order to break down the sugar (or starch) and release the energy they need to grow. The cells in the leaves, trunk, branches, and twigs absorb oxygen from the air. The cells in the roots absorb oxygen from the soil. (Without oxygen, tree cells would die. That's why many trees drown if their roots become waterlogged.)

Get to Know a Tree!

Choose a tree to observe and study.

Objectives:
Observe a specific tree.
Talk about how a tree might change over time.

Ages:
Primary, Intermediate, and Advanced

Materials:
- ***spiral notebooks (one per person)***
- ***clear contact paper (optional)***
- ***drawing paper***
- ***pencils***
- ***glue (optional)***
- ***crayons (optional)***

Subject:
Science

(Idea adapted with permission from *Project Learning Tree*, a supplementary activity guide for grades K through 6, co-sponsored by the American Forest Institute and the Western Regional Environmental Education Council.)

By "adopting" their own trees, your kids can take a close-up look at the features of trees and the ways they grow and change over time. To get the kids started, take them outside and have each of them choose a tree to keep track of for the next several weeks or months. (If there aren't many trees to go around, try having groups of three or four kids choose trees together.)

Give each person a spiral notebook and have the kids visit their trees on a regular basis—for example, once a week for a month or once a month throughout the year. Each time the kids visit their trees they can use a new page in their notebooks to make observations, glue down samples of the trees' leaves, write poems about their trees, draw pictures of their trees, and so on. Here are some examples of activities the kids could do and the kinds of questions they could answer in their notebooks:

- Draw a picture of your tree and write a paragraph describing what it looks like and where it's located. Do you know what kind of tree you've adopted? (Older kids can use a field guide to help them identify their trees.)
- Do you see any animals or signs of animals in, on, or near your tree? (Don't forget insects and other small animals!) If you do see animals, what are they doing?
- Are there any fruits or seeds on your tree? If so, draw a picture of what one of them looks like. What time of the year is it when your tree bears its fruit and/or seeds? (Ask older kids if they can say how the tree's seeds might be dispersed. For example, some seeds get to new areas by floating in water. Others sail on the wind. And some get eaten by animals, which deposit the seeds unharmed in their droppings.)
- Collect a leaf or some needles from your tree. (Each person can lay his or her leaves on a small piece of construction paper and cover them with a piece of clear contact paper. Have the kids glue their mounted leaves onto a page in their notebooks.)
- Write a paragraph describing any changes you see in your tree each time you visit it. What do you think might be causing the tree to change?
- If the leaves of your tree change colors in the fall, collect some of the fall leaves and paste them into your notebook. (See tips for covering leaves with contact paper, above.)
- Examine your tree's bark closely and write a sentence or two describing it. Put a piece of paper over a section of the bark and make a rubbing by coloring the paper with a crayon. Glue the rubbing into your notebook.
- Draw a picture of how your tree looks in winter.
- Write a poem about your tree.
- Have someone take a picture of you standing next to your tree. Glue the picture into your notebook.
- Are there any flowers on your tree? If so, draw a picture of one of them. What time of year is it when your tree has flowers?
- Draw a picture of your tree's buds in the winter and again in the early spring.

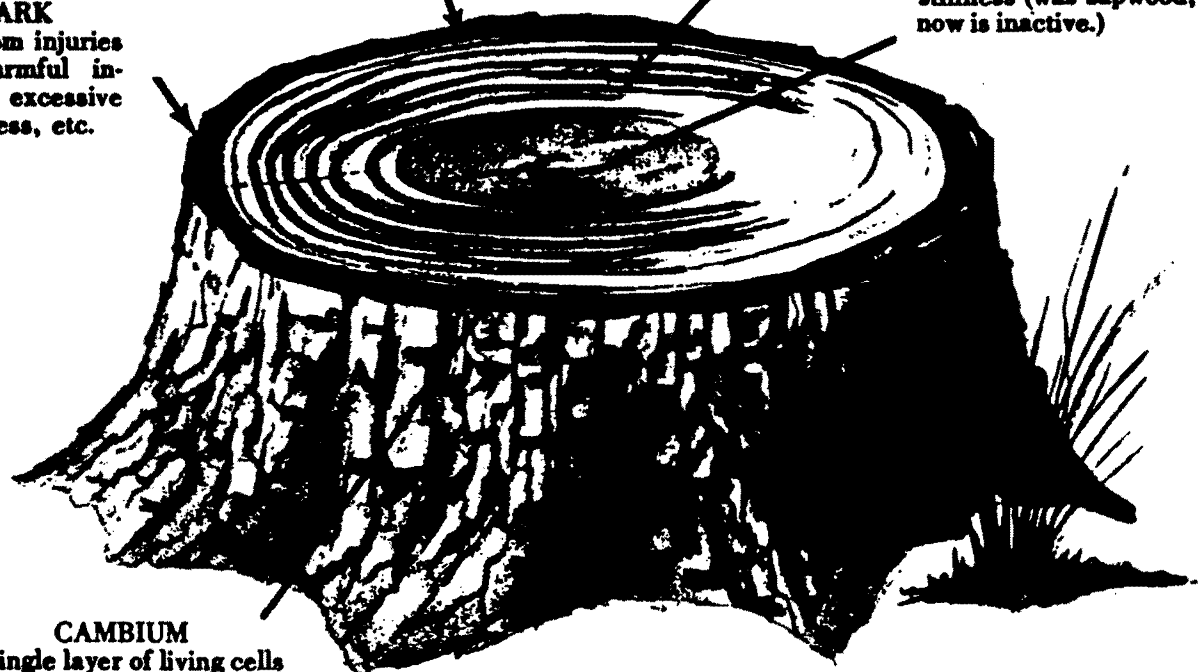
Luise Woelflein

SAPWOOD
(Xylem) carries sap (water and dissolved minerals and nitrogen) from roots to leaves, where sugar is made. The summerwood is usually denser than the springwood.

INNER BARK
(Phloem) carries sugar made in the leaves down to the branches, trunk, and roots, where the sugar is made into other substances vital for growth.

HEARTWOOD
Gives extra strength and stiffness (was sapwood, but now is inactive.)

OUTER BARK
Protects tree from injuries by animals, harmful insects, diseases, excessive heat, cold, dryness, etc.



CAMBIUM
A single layer of living cells between bark and wood where growth in diameter occurs. It forms annual rings of new wood inside and new bark outside.

Parts of a Log

Build a Tree

As a group, act out the parts of a tree.

Objectives:
Describe the parts of a tree. Explain how each part works.

Ages:
Primary and Intermediate

Materials:
- ***slips of paper***
- ***chalkboard or easel paper***

Subject:
Science

In this activity, your group can learn about the parts of a tree by acting them out and building a "human tree." Before you begin, copy these words onto separate slips of paper and put them in a hat (you should end up with 30 slips):

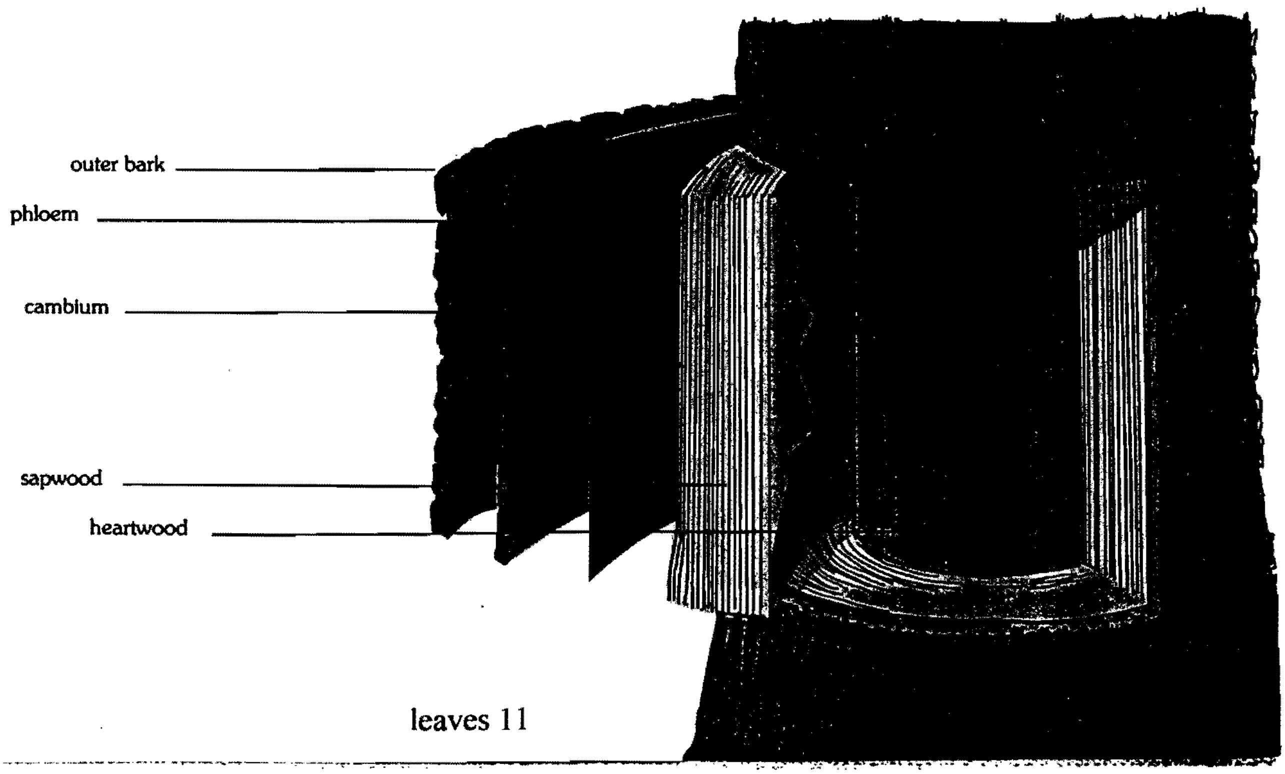
- heartwood (1)
- sapwood (2)
- cambium (4)
- phloem (8)
- outer bark (12)
- taproot (1)
- lateral roots (2)

(Adjust the number of slips you make according to the size of your group.)

Next copy the diagram below on the chalkboard or easel paper and label the parts. Then, using the background information on pages 6 and 7, discuss each part with the group, explaining how each functions and where it's located on a tree.

Now take the group outside to a large open area and explain that everyone will work together to "build" a tree. First have each person pick a part to play by reaching into the hat and pulling out a slip of paper. Next have the kids practice any sounds or movements suggested for their parts and then have them slowly build the tree, layer by layer. Once the tree is built, have them act out their parts together.

1. Have the child playing the part of the *heartwood* cross his or her arms and stand in the center of the play area. Explain that this child represents the heartwood of the tree.
2. Next have the child playing the *taproot* sit down at the foot of the heartwood kid. Explain that this person represents the deep taproot that most trees have.
3. Have the *lateral roots* lie down on their backs, spreading out from the taproot with their feet toward the heartwood. (Have the lateral roots make slurping sounds.)
4. Have the *sapwood* kids join hands to make a ring around the heartwood. Position them so they stand between the lateral roots. They should face in, toward the heartwood. (Have the sapwood kids pretend they are drawing water up from the roots by lowering their hands, still joined, and then raising them above their heads.)
5. Have the *cambium* kids join hands and form a large circle around the sapwood. (Have the cambium kids chant, "we make new cells, we make new cells, we make new cells.")



6. Next have the *phloem* kids join hands and form a larger circle around the cambium. (Have the phloem kids pretend they are transporting food down from the leaves by starting out holding their arms above their heads, then lowering them and raising them again.)
7. Finally, have the *outer bark* kids form a circle around the entire tree, facing outward and holding hands.

Once everyone is in position, ask the kids to go through their motions: the roots taking up water from the soil, the sapwood transporting the water up the trunk to the branches and leaves, the phloem carrying food down from the leaves to the trunk and roots, and the cambium chanting "we make new cells." Afterward, lead a short discussion about the different parts of the tree to make sure everyone understands what each part does.

(This idea was adapted with permission from Joseph Cornell, author of *Sharing Nature with Children*, Ananda Publications, Nevada City, California 95959.)

learning about trees

How can we learn about trees? By looking at them, listening to them, touching them, smelling, and sometimes even tasting them (with caution); by appreciating their roles in the natural world, as well as their importance to us; by being curious about them with enthusiasm for discoveries.

As a starter, here is a specific tree activity, one I have often used as an introduction to tree studies. It is designed for a class of twenty-four fifth-graders in a school that has a yard large enough to accommodate a fair number of trees, but it can be geared for older or younger children, for adults, or otherwise altered to suit particular situations. Its purpose is to sharpen observation skills, leading toward basic tree identification.

One way to learn about a tree is to sit beneath it and write down your observations and feelings about it.

introductory tree activity

Materials: Leaves from four different kinds of common trees in the school yard (six leaves from each kind of tree, twenty-four in all), paper bag, four large index cards, four pencils.

Procedure:

1. Form four groups, each with six students, by leaf matching. Have each student take a leaf from the paper bag, find the other students with the same kinds of leaves, and group themselves accordingly.

By finding the matching leaves, the students on their own have already started leaf observation.

2. Each group makes leaf descriptions. Give each group a card and a pencil and have them list words that describe their leaves.

Encourage the students to observe and list different kinds of descriptive words. What shape are the leaves? What color? How big? Would they like to invent a name for the tree that grew their leaves?

3. Groups exchange descriptions and leaves. Have them put the leaves back together in a pile. Give each group a leaf description card made by one of the other three groups, asking the students of each group to find the kind of leaves that their new card describes. Then have the groups read the descriptive words aloud, showing the matching leaves.

Since more observation techniques have been used, now is the time for discussing and sharing the results. Which descriptive words seem especially apt? Why? By now the students, through their own observations and thinking, have become familiar with four different kinds of leaves.

4. Go outside and identify trees by their leaves. Have the students identify and count the trees in the school yard that have the same kinds of leaves as those their group described on their first card.

Here, earlier observation work is given practical application.

5. Record the numbers of the trees found by the students and discuss the results.

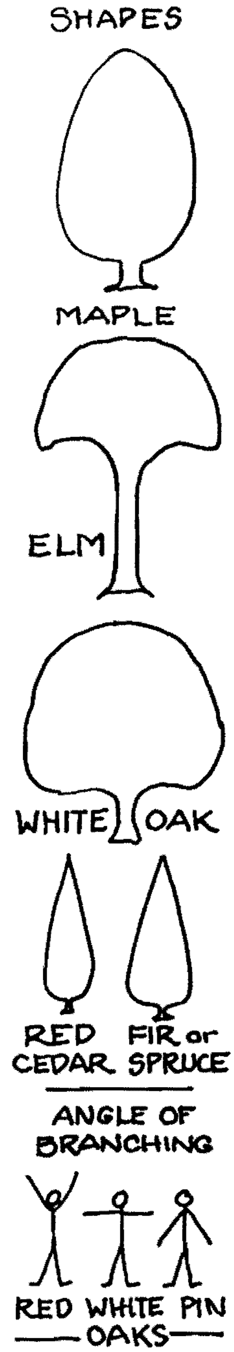
The emphasis should be to stimulate the students to identify trees using their own observations, rather than to make a highly accurate survey. Do any students have wide disagreements about the number of one kind of tree? Ask them to go off together to resolve their differences. Perhaps a student included some trees that did not have leaves that truly matched, or maybe a student walked right under some of the trees without looking up and spotting them. Did any of the students notice identifying features of a tree other than its leaves? That can be a starting point for further studies of tree identification.

Until this point, we have not needed to know the names of the four trees. Now, have the students look up the trees in identification guides. Curiosity may be such that the students will want to know the scientific names as well as the common names.

There can be many variations of this activity. The numbers of trees, leaves, children, and groups can easily be changed. The groups can make more sophisticated descriptions of their leaves, using technical leaf terms (simple, compound, toothed, lobed, elliptic, and so on). If it is not feasible for the class to go out to identify trees, omit steps 4 and 5. If the students already have had some experience with tree identification, stress accuracy in the outside tree survey. With very young children, try a simple matching leaves and trees walk. Give each child a leaf and go on a walking hunt to find trees with matching leaves. Four-year-olds feel excited and proud when they can identify "their" trees.

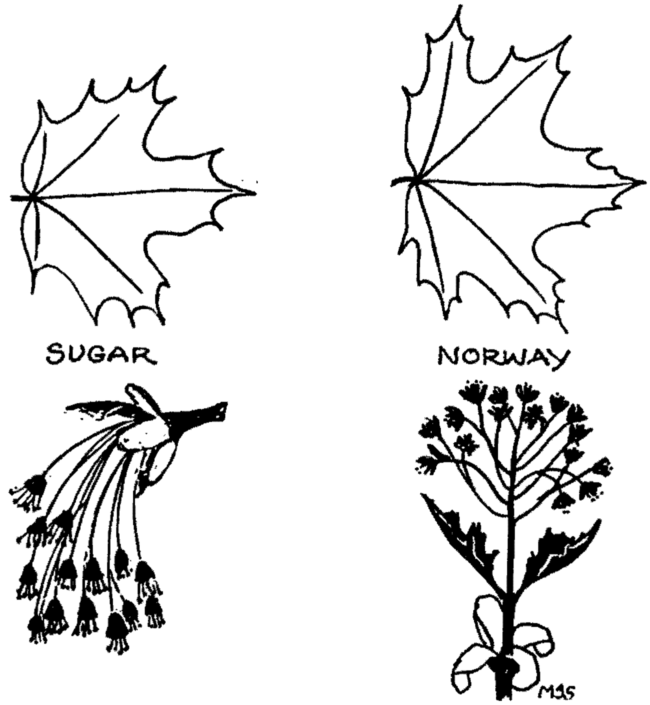
What other factors besides leaves are considered in tree identification? One of the most obvious is habitat. You will not see a palm tree growing naturally in Montana, or a ponderosa pine in Florida. Knowing the likely areas where different trees may be found, or not found, is helpful. A pine in Florida, for instance, will not be a ponderosa pine, which is a western tree; but it could be a longleaf or a slash pine, both of which are southern species. Trees are common to certain ranges and often have preferred environments within a range. The silver maple is found in the eastern half of the United States, while the Rocky Mountain maple grows where its name indicates. Within these ranges, the silver maple is often found in or near wetlands; the Rocky Mountain maple thrives at higher altitudes, especially in the southern part of its range.

Various tree features are helpful in identification. In addition to leaf shape, the overall tree shape is indicative. The typical cone shapes of many evergreens, for instance, are markedly different from the rounder shapes of deciduous trees. Branching patterns differ. The twigs of most trees grow at alternate intervals from the branch, but some have twigs that grow opposite each other. Tree barks vary.



Almost anyone who sees a tree with white bark will think of birch. Trees with the rough brown variety of bark can seem confusing, but closer inspection will reveal differences. Tree flowers are another identifying clue. We can recognize the magnolia in spring by its showy flowers, but did you ever try to distinguish one species

2 MAPLE TREES



METHOD OF GROWTH ON TWIG

of maple from another by the flowers? Maple flowers differ, even though they are inconspicuous, as are many tree flowers. Some tree fruits and seeds also are obscure, while others are obvious; but they all help with identification. Certainly anyone finding a tree in fall covered with delicious-looking red apples will be able to identify the tree!

Suppose you are outside with a group and someone asks, "What kind of tree is that?" If you don't know, never be afraid to say so; this can breed a genuine curiosity to find out. "Let's look it up" or "let's see how it differs from other trees" are natural responses that can lead not only to the name of the tree, but also to understanding and knowing the tree.

preserving leaves with wax paper

Materials: Leaves, wax paper, scissors, old newspapers, electric iron.

Procedure: Cut pieces of wax paper. Arrange leaves between two pieces, and place these between several sheets of newspaper. Iron with a warm iron.

This is particularly effective with brightly colored autumn leaves, as the colors will last. Hang them up in a window for an attractive display. Try making place mats in this way. Wax paper sandwich bags may also be used. Simply place the leaves in the bags between newspaper sheets, and iron them.

preserving leaves with clear self-adhesive plastic

Materials: Leaves, heavy paper or cards, clear self-adhesive plastic, scissors.

Procedure: Arrange leaves on the paper or cards. Cut the plastic into pieces the size of the paper or cards. Peel the plastic and cover the arrangement with it, pressing it down carefully.

Very young children need help in peeling and applying the plastic. This activity is good for all ages, including the elderly, who often enjoy making decorative souvenirs on fall outings as a reminder of a pleasant trip. The colors last well. Make other leaf items with the plastic, such as postcards, bookmarks, or place mats. Put a leaf between two pieces of the plastic for a window decoration, or cut it into an oval shape, punch a hole at one end, and hang it as a pendant from a necklace made of string or yarn. Make leaf decorations to go around tin cans or other containers to be used as pencil and other kinds of holders. Holders can also be decorated with other print-making methods—using paint, making spatter prints or leaf rubbings, or using blueprint paper.

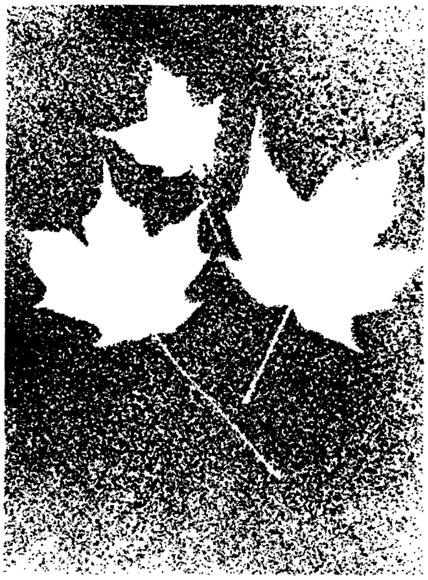
leaf prints using paint

Materials: Leaves, paint (water-based block-print ink, or oil-based for older children), plates, brayer (roller), old newspapers, paper, or other material to be printed.

Procedure: Put a leaf on the newspaper. Pour paint into the paint container, dip the brayer into the paint, and apply the paint to the leaf. Put the leaf, paint side down, on the article to be printed. Cover with a sheet of newspaper and press the leaf down gently. (It may help to use a rolling pin or to roll a straight-sided bottle over the leaf.) Remove the leaf to reveal its print.

Choice of paint colors and arrangements of leaves offer many creative alternatives. A variety of items can be decorated by this technique, from notepaper and place mats to wall hangings and curtains.

This leaf print curtain was made with fabric paints by the family together on a summer afternoon in the country. It reflects the plants that were at hand.



A leaf spatter print.

leaf spatter prints

Materials: Leaves, paper, paint (thinned poster paint, watercolors, or colored ink), old toothbrush, small piece of wire screening or a thin stick (about pencil length).

Procedure: Arrange leaves on the paper. Dip the toothbrush into the paint and let any drips fall back into the paint container. Hold the toothbrush several inches above the paper and rub the bristles against the screening or stick, spattering paint on the paper around the leaf.

Practice first, so that the spattering will land where you want it, not on yourself. You can also use a can of spray paint (without fluorocarbons, which scientists say are harmful to the environment). Either method produces pleasing leaf silhouettes.

leaf rubbings

Materials: Leaves, wax crayons, sheets of paper (not too heavy).

Procedure: Place leaf under a sheet of paper. Remove paper from a crayon and rub the crayon sidewise on the paper over the leaf. The leaf pattern will appear on the paper.

This technique is especially suitable for younger children. Even three-year-olds can do it with very little adult assistance, and they enjoy the magic-like appearance of the leaf pattern as they rub. For older children, leaf rubbings are an effective way to make a collection showing varieties of leaves.

matching leaves

Materials: Different kinds of leaves, several of each.

Procedure: Have each child take a leaf and then find the other children who have matching leaves.

This is a handy method for dividing a group arbitrarily into smaller groups (as in the introductory tree activity earlier in this chapter). Variations are possible. Use twigs from different kinds of evergreens. Cut a variety of leaves into halves; give a half to each child who then finds the child with the other half.

leaf sorting

Materials: Leaves.

Procedure: Sort the leaves into categories.

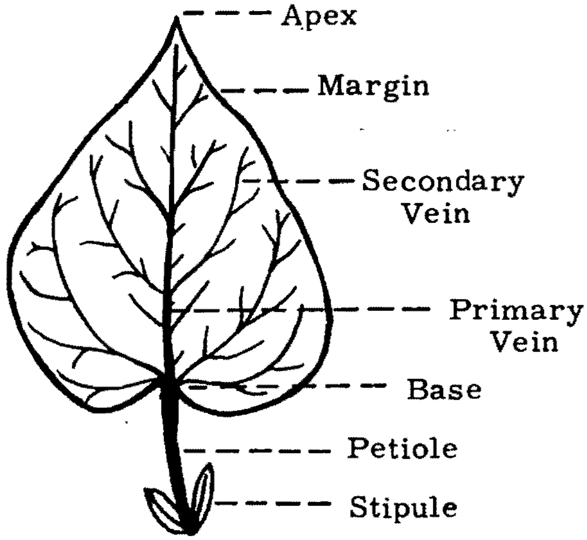
There are numerous possible categories: size—large to small, wide to narrow, long to short; texture—rough to smooth, thick to thin; insect damage—leaves with the most holes to those with the least, leaves with the most bumps or other kinds of damage; colors—reds, yellows, and other shades of autumn foliage, or variations of green; smell—leaves with a pleasant smell, with an unpleasant smell, with no smell. Most of these categories can be handled by young children. Older children can manage more exact or complicated versions, or they can sort leaves using technical leaf terminology, by shape (narrow, oblong, elliptic, heartshaped, and others) or by appearance of edge (wavy, lobed, fine-toothed, and so on). Can anyone find two leaves that are exactly alike? Can anyone find leaves that show no sign of insect activity (a question for late summer or fall)?

leaf old maid

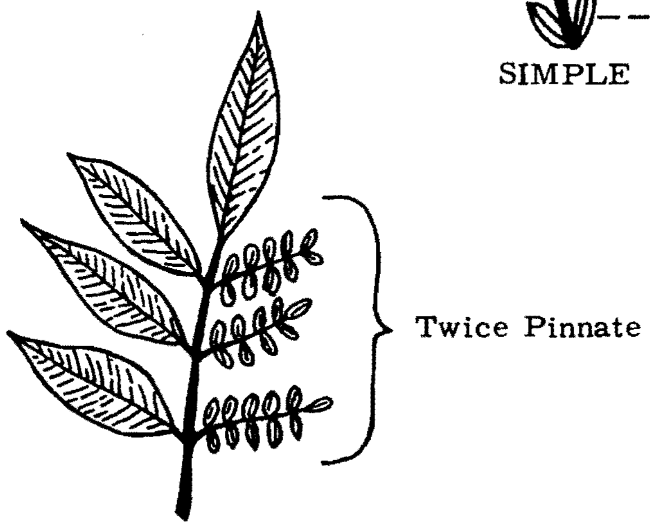
Materials: Twenty-one cards, clear self-adhesive plastic, two each of ten different kinds of leaves, one other kind of leaf, scissors.

Procedure: Put a leaf on each card and cover with the plastic. Play Old Maid using the cards; there will be ten matching pairs and one singleton, which is the "old maid."

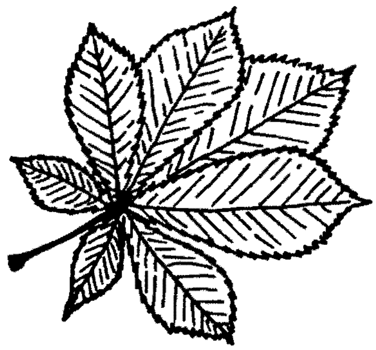
Perhaps the children will change the name of the game, for instance, to Old Oak (if an oak is the singleton leaf). Other variations are possible. Make sets of four cards with the same kinds of leaves and the children can play Fish. Probably their ingenuity will lead them to create other variations.



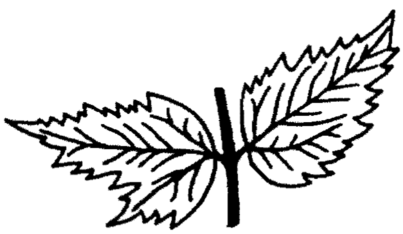
SIMPLE



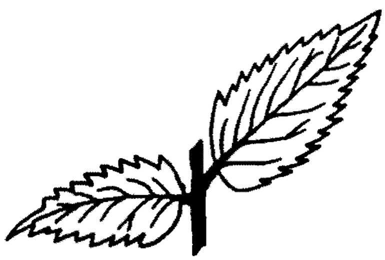
Pinnately Compound



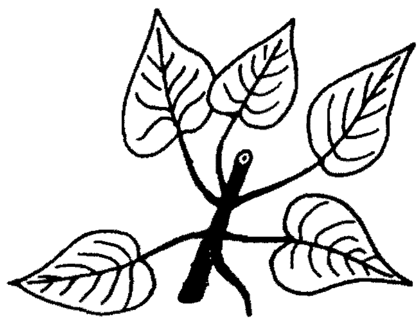
Palmately Compound



Opposite

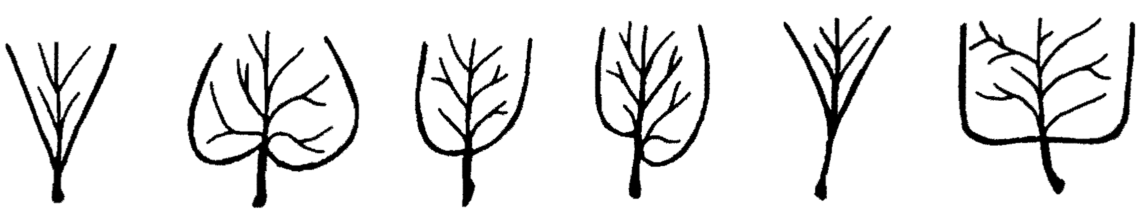


Alternate



Whorled

LEAF BASES



Acute Cordate Rounded Oblique Acuminate Truncate

Keying Out Trees

"Key out" the children in your group, then identify some trees using a simple leaf key.

Objective:
Use a key to identify trees.

Ages:
Intermediate and Advanced

Materials:
- *copies of pages 20, 21, and 22*
- *chalkboard or easel paper*
- *pencils or pens*
- *index cards (optional)*
- *construction paper (optional)*
- *bulletin board (optional)*

Subject:
Science

How can you figure out the name of a tree you're looking at if you've never seen that kind of tree before? You can use a tree identification key. A tree key is a series of phrases, each of which points out a certain feature of a tree, such as the shape of its leaves, color of its bark, and so on. By determining which phrases apply to your tree, you can identify the tree you are looking at. (There are also keys for wildflowers, birds, shrubs, fish, and many other living things.)

PART 1: "KEYING OUT" KIDS

Using a "people key" is one way to teach your group what a key is and how it works. The tree-shaped diagram on page 20 is a modified key for identifying people. Before you get started using the people key, copy the tree-shaped diagram onto a chalkboard or a large piece of easel paper. (You can also make a more permanent display by sketching the diagram on a bulletin board covered with construction paper.)

Begin the activity by asking the kids how they can tell different people apart. (by their sex, hair color and texture, eye color, height, and other physical features) Why isn't clothing a good way to tell people apart? (because people can change their clothes or wear identical clothes) Then pass out copies of page 20 and have the kids follow along as you explain how the "key" works.

Each of the branches represents a physical feature that helps to tell people apart. By starting at the trunk and moving up the branches that correctly describe the person being "keyed out," you will reach the very tip of an outermost branch. This is the person's position in the key. For example, if you were keying out a blue-eyed girl with straight brown hair and freckles, you would first move up the branch marked "female." At the fork for hair color, you'd climb up the branch for brown hair. After moving up the branch for straight hair and then the branch for blue eyes, you'd finish up at the end of the "freckles" branch. This is where you'd write that person's name. As an example for the kids, try keying out yourself. (This key is designed for an average group of children. If it doesn't fit the individuals in your group, you can adapt the branches already on the tree or add more specific characteristics.)

Now divide the children into pairs. They will work together to key out each other on their diagrams. Carefully looking at their partners, they should go through the key to find each other's position on the key and then write their names at the ends of the branches.

After everyone is finished, have the pairs go up to the large diagram one at a time and fill in their names. (If you're making a bulletin board, the kids can write their names on index cards or leaf-shaped pieces of construction paper, then tape or staple them on the board.)

You may find that several people have been placed at a single position on the key. If this happens, call these children to the front of the room. What other characteristics could identify them? (height, short or long hair, light or dark shade of skin or hair, and so on)

Once everyone's name is on the diagram, go over it as a group. To test the accuracy of your "people key," invite someone into the room who doesn't know the names of the children. Ask one of the children to volunteer, and have the guest "key out" the child to determine his or her name.

PART 2: LEAVES

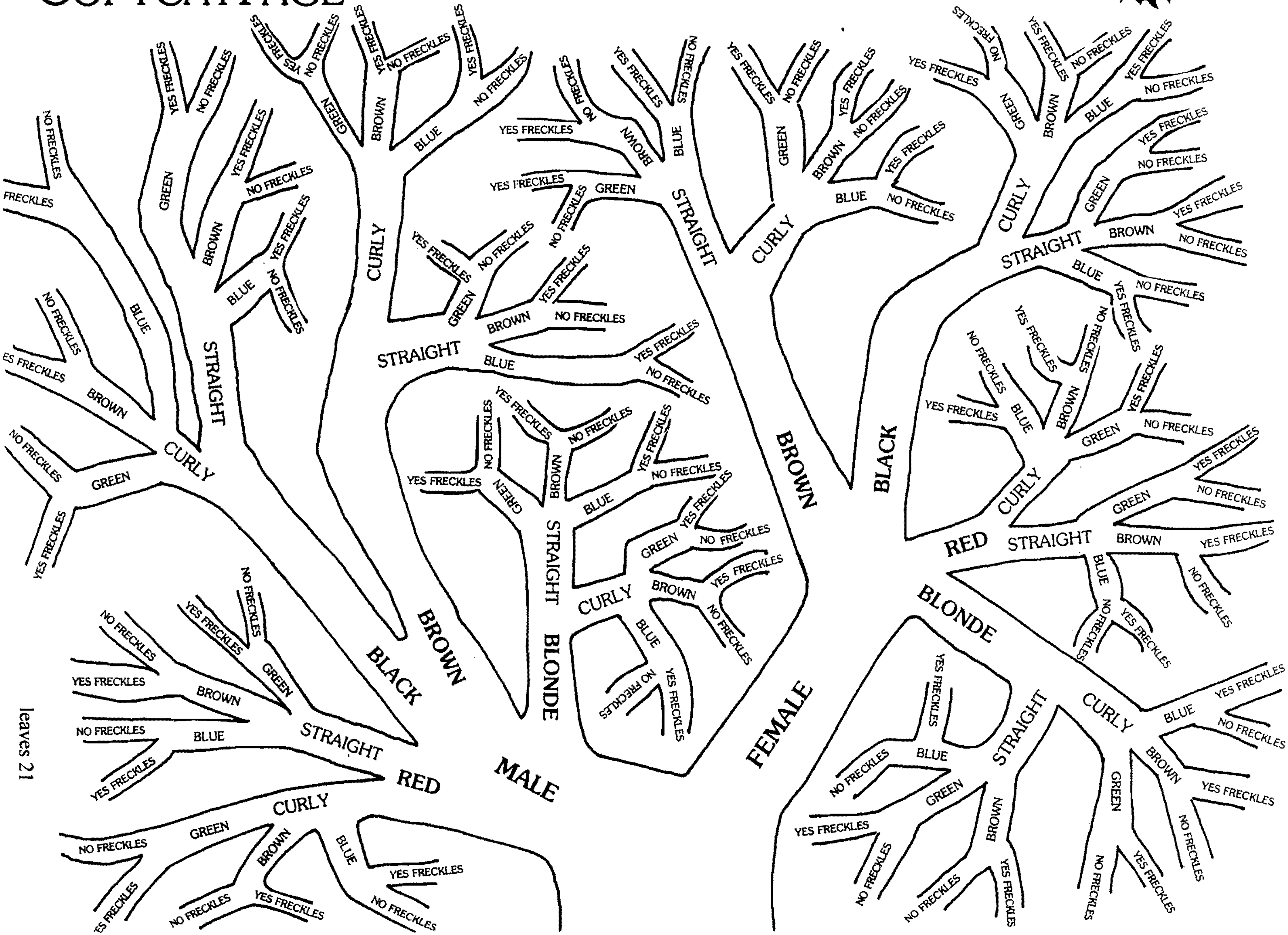
Now that they understand how a key works, let your kids try keying out trees by looking at leaves. Give everyone copies of pages 21 and 22. Each of the boxes on page 22 contains a picture of leaves. Explain to the kids that they will identify the type of tree each leaf came from by using the leaf identification key.

Before the kids try to key out the nine leaves, copy the illustrations of the terms found on the bottom of page 21 on the chalkboard or easel paper. Then go over each of the leaf terms with them as they follow along on their papers. (Some children may have trouble with these terms. Before they try keying out the leaves, you may want to go over each of the leaf drawings on page 22, discussing the shape of each leaf and whether it is compound or simple and opposite or alternate.)

Next have the kids look at the dichotomous key on page 21. Explain that the word *dichotomous* comes from two Greek words that, together, mean "to divide into two parts." A dichotomous key is based on the idea of making a choice between two alternatives. As with most keys, each pair of phrases in the leaf key we've provided describes different features. But only one of the phrases correctly describes the leaf being keyed out. As they're keying out their leaves, each person will need to decide which phrase applies to the particular leaf he or she is trying to key out. Explain that this "correct" phrase will either guide the kids to the next pair of phrases or state the name of the tree the leaf grows on.

Now set a time limit and let each of the kids try to key out all nine leaves. As they identify each leaf, they should write the name of the tree it comes from on the line under the drawing.

When the time is up, go over the answers (listed on page 77) with the group.


MALE
FEMALE
BLACK
BROWN
BLONDE
RED
CURLY
STRAIGHT
GREEN
BROWN
BLUE
YES FRECKLES
NO FRECKLES

LEAF KEY

1. Leaves are shaped like needles . . . . go to **2**
Leaves are broad and flat. . . . . go to **3**

2. Long needles grow in bunches of five. . . . . WHITE PINE
Needles are short, and grow singly along the branch . . . . SITKA SPRUCE

3. Leaves are opposite . . . . go to **4**
Leaves are alternate . . . . go to **5**

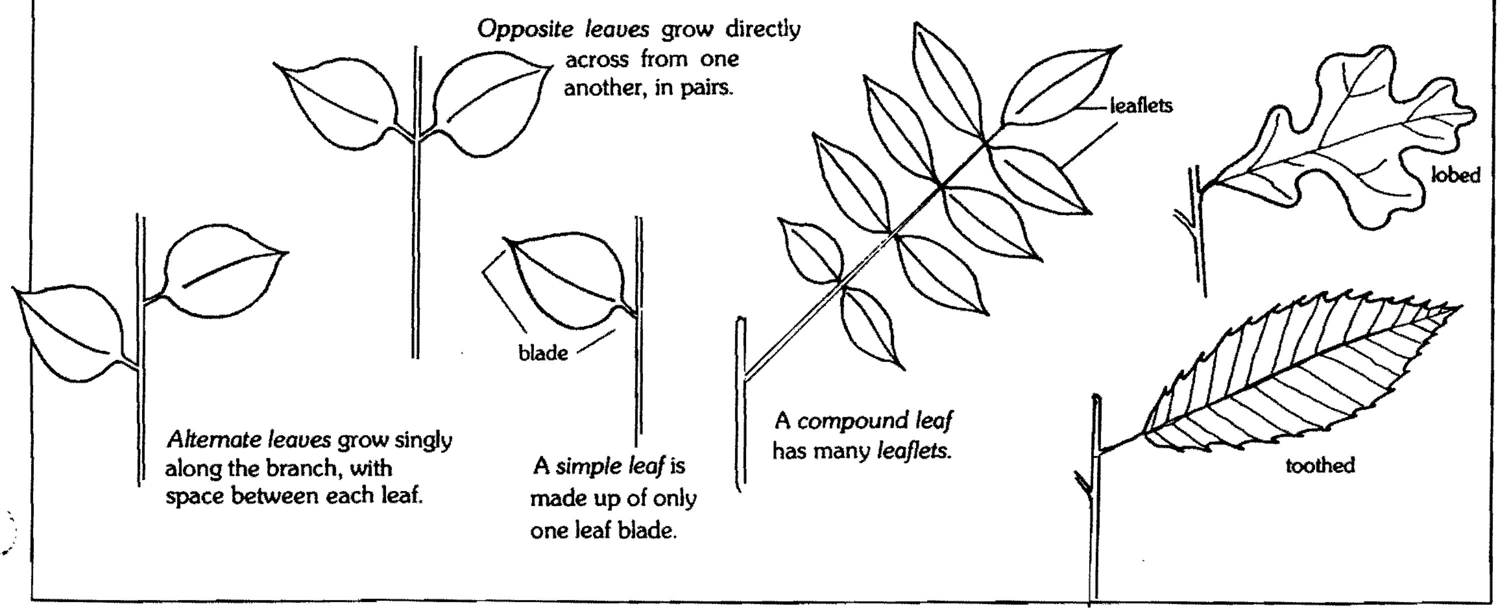
4. Leaves are simple . . . . SILVER MAPLE
Leaves are compound. Leaflets grow around the stem in a circle. . . . . HORSE CHESTNUT

5. Leaves are simple . . . . go to **6**
Leaves are compound . . . . go to **8**

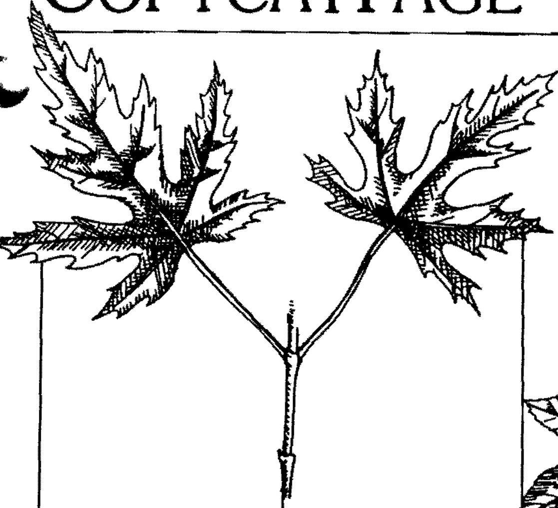
6. Leaves are lobed. . . . . WHITE OAK
Leaves are toothed . . . . go to **7**

7. Leaves are long and slender . . . . WEEPING WILLOW
Leaves are rounded . . . . CHOKE CHERRY

8. Branches have thorns. . . . . HONEY LOCUST
Leaflets are toothed. . . . . BLACK WALNUT

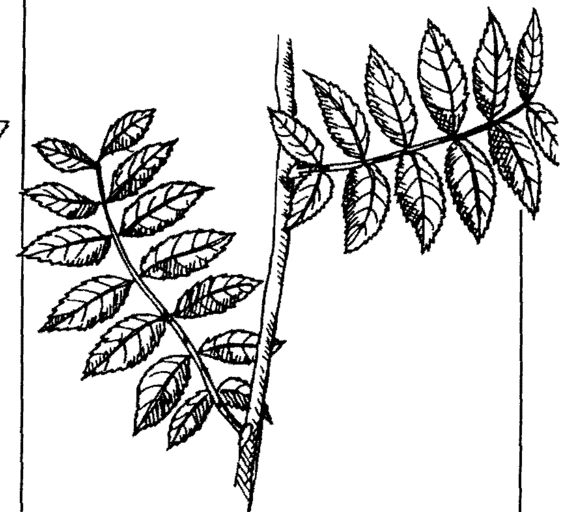


COPYCAT PAGE KEYING OUT TREES—PART 3



1. ________________

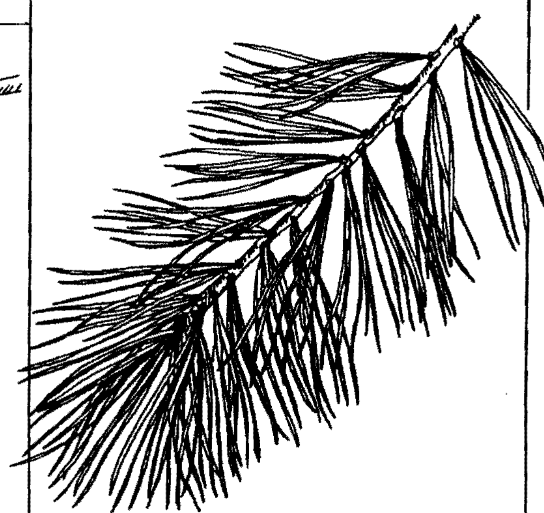
2. ________________



3. ________________

4. ________________

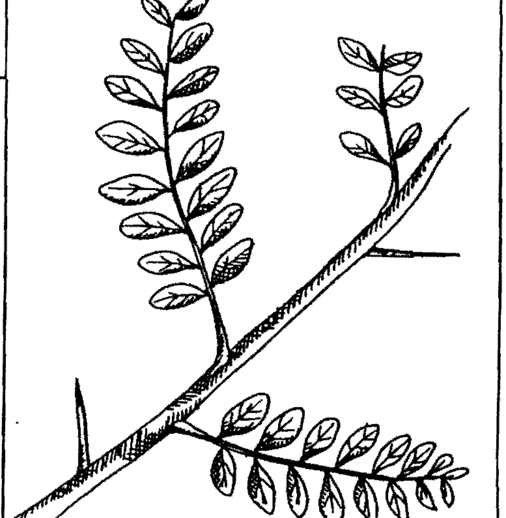
5. ________________



6. ________________

7. ________________

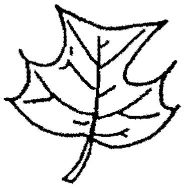
8. ________________

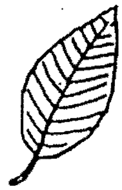


9. ________________

LEARNING TO KNOW THE TREES

THIS KEY IS EASY ----- TRY IT!
Here's all you have to know to use it.

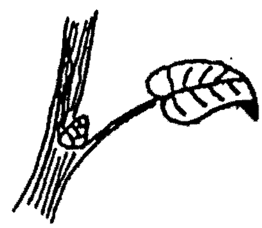
If the leaves have lobes  See SECTION A.

If the leaves do not have lobes  See SECTION B.

If the leaves are compound  See SECTION C.

Look at a leaf. Decide whether it is lobed, not lobed or compound. Now turn to the indicated section. Remember that leaves on any one tree of any species vary in size and shape, and from tree to tree. The leaf forms used in this key can be regarded only as indicating the typical character of the leaves of any species.

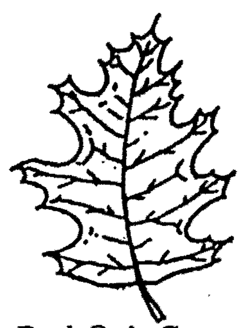
NOTE: To help decide whether a leaf is compound or not; one must know that a leaf is that structure which occurs past the axillary bud.



SECTION A. - LEAVES WITH LOBES

1. OAKS - If the leave looks like either of the following it is an oak.

a. White Oak Group



b. Red Oak Group

Oaks are found on moist rich soils and on dry slopes. They are usually a medium sized tree about 60 to 80 feet high. The nut from an oak is called an acorn. Acorns are eaten by many wild animals such as turkeys, grouse and squirrels. Wood from oak trees is one of the best for building purposes. In colonial times it was used extensively for ship-building. The bark of the oak contains tannin which is used in the hidetanning industry.

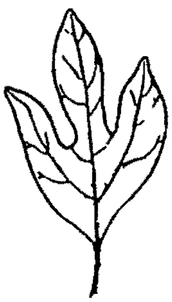
2. TULIPTREE - If the leaf looks like this, it is a Tuliptree.

Tuliptrees grow best on moist rich soils and therefore are often found on such sites. This tree is the tallest of the eastern hardwoods reaching heights of 100 feet. There is but one kind of tuliptree in North America. The only other kind occurring in the entire world is found in China. The tuliptree is an important lumber tree especially for veneer. From the inner bark of the roots chemists make hydrochlorate of tulipiferene, a heart stimulate. The Indians called this a "canoe tree" because they made dugouts from it.

3. MULBERRY - If the leaf looks like this, it is a Mulberry.

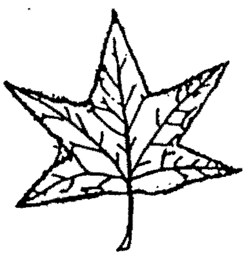
This tree is found on bottom lands or moist hillsides. The fruit of this tree resembles a blackberry and is sweet and edible. This is a good tree to plant if one wishes to attract birds and small animals. The bark of this tree is fibrous and some Indians wove cloth from these fibers. The wood is durable and was used for fence posts and wooden pins. The leaves of the white mulberry are used as food for silkworms.

4. SASSAFRAS - If the leaf looks like this, it is a Sassafras.



This is a widespread and aggressive weed tree often found growing along the edge of a woods. The wood of the sassafras is soft and was used by American Indians to make dugout canoes. Sassafras has been famous since pioneer days as a tea which is made by boiling the bark of the roots. Some pioneers mixed sassafras tea with molasses and allowed the liquid to ferment; this was then drunk as beer.

5. SWEETGUM - If the leaf looks like this, it is a Sweetgum.



This common bottomland tree also grows on dry soils. Resin obtained from this tree is used in the perfume industry. The seeds are eaten by a variety of wildlife. This tree is often grown as an ornamental and is quite beautiful in the autumn when leaves turn a bright scarlet.

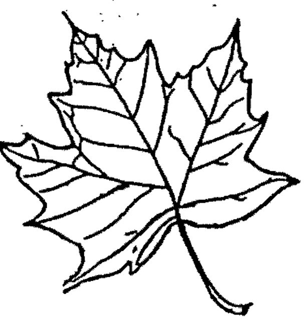
6. SYCAMORE - If the leaf looks like this, it is a Sycamore.

The wood from this tree is very tough and is used for such items as butcher's blocks where wood difficult to split is used. This tree is one of the commonest stream-bank trees in Ohio. It grows best on moist sites. When the reddish-brown bark of this tree peels away, a creamy gray color is revealed. This tree also was used to make canoes.

7. HAWTHORN - If the leaf looks like this, it is a Hawthorn.

There are some 800 different varieties of this tree in North America. These trees often invade pastures and are a constant headache to farmers. On the other hand, the fruits are eaten by many wild animals including song birds and game animals. Many of these are planted as ornamentals because of their abundant flowers and bright red fruit. When identifying hawthorns be careful of the thorns.

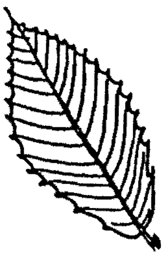
8. MAPLE - If the leaf looks like this, it is a Maple.



Maples usually occupy moist sites. The best known is the sugar maple which is probably the commonest and most important of the maples. When settlers arrived in America, the Indians taught them how to make sugar and syrup from the spring sap. Hence, an entire industry was built because of this tree. We, in Ohio, have an enjoyable maple sugar festival at the town of Chardon.

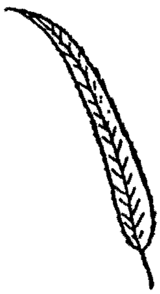
SECTION B. - LEAVES WITHOUT LOBES

1. BEECH - If the leaf looks like this, it is a Beech.



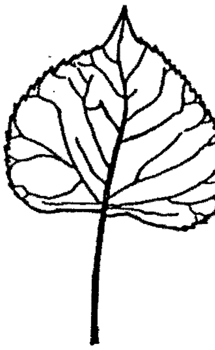
This tree it probably more easily identified by its smooth gray bark. In the Ohio Valley, during pioneer days, beech leaves were used to stuff mattresses. They were preferred to straw because the dried leaves didn't get musty. Ashes from the burned wood were used in soapmaking. This tree is very shade tolerant and has the same life requirements as the maple. Hence, they are often found growing together. It has been said that beech trees are never struck by lightning.

2. WILLOW - If the leaf looks like this, it is a Willow.



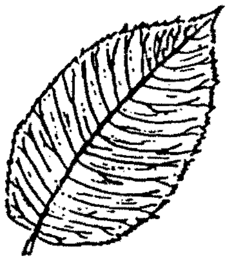
Willow wood is soft and of little commerical value. But this long slender leafed tree is important in other ways. For example, it preserves stream banks by anchoring the soil and not allowing the stream to wash it away. The willows found along a stream are usually Black Willows. Weeping willows are beautiful as ornamentals. American Indians used to make fishing lines from the inner bark of the willows.

3. COTTONWOOD - If the leaf looks like this, it is a Cottonwood.



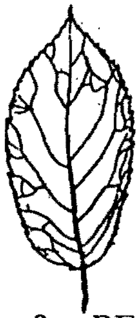
This is a common stream-bank tree in Ohio, although it can be found on drier sites. An old Indian legend has it that one day a chief discovered the design for a tepee by rolling a cottonwood leaf in his fingers producing a small cone-shaped pattern. Indian children still fashion toy tepees in this way. When this tree is in bloom the "cotton", when blown by the wind, can produce a summer "snow storm".

4. ELM - If the leaf looks like this, it is an Elm.



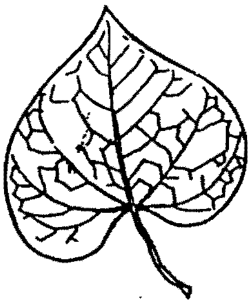
This is one of the best known and widespread of our native trees in the eastern United States. This tree, in prior years, was preferred by many for shade tree planting. Today it is threatened with extinction because of a fungus disease called Dutch elm disease. This disease came from Europe and is carried by a small beetle which lives under the bark of trees. The American Indians used the inner bark of elms to make ropes.

5. BLACK CHERRY - If the leaf looks like this, it is a Black Cherry.



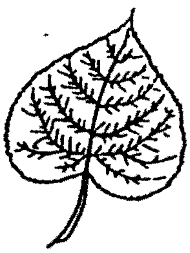
This is another tree perhaps more easily identified by its bark. The bark is black in color and made up of rough scaly plates, perhaps better described as "chinky-chunky" bark. Black Cherry is one of the most valuable trees found in Ohio. The hard wood is used for furniture and interior finish. I have read that the fruit is sometimes used to flavor rum and brandy.

6. REDBUD - If the leaf looks like this, it is a Redbud.



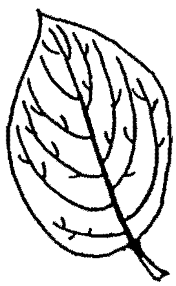
This tree, because of its beautiful red bloom, is often planted as an ornamental. In Asia this tree is called a Judas Tree. According to an old myth it was this tree on which Judas hanged himself. When this happened, the white bloom of the tree turned red, because in shame, the tree blushed.

7. BASSWOOD - If the leaf looks like this, it is a Basswood.



The wood of this tree is soft. The Iroquois used this wood to carve falsefaces. They made rope and fishing line out of the inner bark. The Indians also used the fresh bark as a bandage for wounds. In Europe, this tree is called Linden.

8. DOGWOOD - If the leaf looks like this, it is a Dogwood.



This is a common understory tree in moist hardwood forests. Because of its beautiful bloom Flowering Dogwood is often planted as an ornamental. This tree holds its fruit well into winter serving as a storehouse for wild animals. The ends of the small branches, if split, can be used as a toothbrush and it is said that they whiten the teeth.

SECTION C. - COMPOUND LEAVES

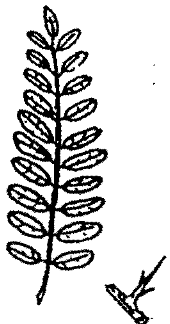
1. HICKORY - If the leaves look like this, it is a Hickory.

Hickory wood is noted for its toughness and ability to stand up under sudden shocks. Because of this, it is the best wood to use for axe handles. Hickory is probably the best firewood obtainable. It makes an excellent campfire, burning down to a hot bed of coals suitable for broiling. Squirrels feed heavily on the nuts.

2. WALNUT - If the leaves look like this, it is a Walnut.

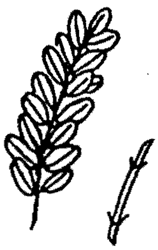
Walnut is a valuable hardwood widely used for furniture. It is an exceptionally fine wood for gunstocks. The fruit husks contain a yellow dye which was used by the pioneers to stain cloth. It has been said that the roots of the Black Walnut give off a substance poisonous to certain plants such as tomatoes.

3. HONEY LOCUST - If the leaves look like this, it is a Honey Locust.



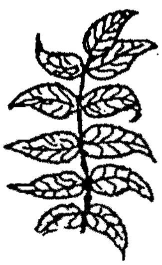
This typically is a bottomland tree. The wood is hard and durable, being used for fence posts and railroad ties. The thorns of the honey locust are usually three branched. The flowers of this tree furnish nectar for honeybees. The seeds are borne in a pod.

4. BLACK LOCUST - If the leaves look like this, it is a Black Locust.



This tree grows best moist on soils of limestone origin. It has been said that the young shoots are poisonous to livestock. The wood is hard and durable and is used by farmers as fence posts. The roots of this tree enrich the soil with nitrogen. The seeds and leaves of this tree are said to be poisonous to humans.

5. SUMAC - If the leaves look like this, it is a Sumac.

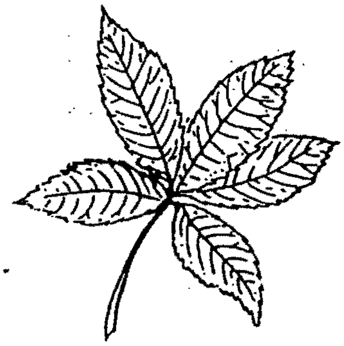


This is a shrub-sized tree. Its male and female flowers are borne on separate trees, hence fruit is found only on the female plants. The bright red fruit clusters are very conspicuous. The fruit tastes like sour apples when the juice is sucked from it. The fruit does not fall off in the winter and therefore is available to a great number of wild animals.

6. BOXELDER - If the leaf looks like this, it is a Boxelder.

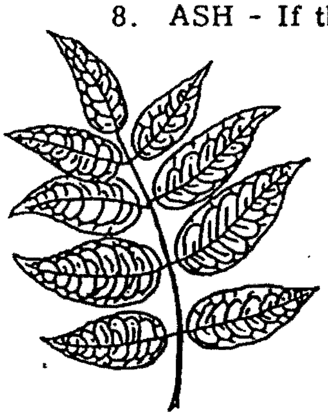
This smallish maple tree grows to a normal height of about 40 feet. This tree grows best on moist sites but is very hardy and can stand extremes of temperature and dry soils. This tree has been much planted throughout the mid-west. This is the only maple with a compound leaf. It is also called an "Ash-leaved Maple".

7. BUCKEYE - If the leaf looks like this, it is a Buckeye.



This medium sized tree is found on the west slopes of the Appalachians and through the Ohio Valley. The flowers, borne in showy clusters, produce large brown seeds (buckeyes). The fresh seeds of this tree are very poisonous to eat and should not be bitten into. Buckeyes strung together make a very attractive necklace, or if hollowed out and a hollow reed inserted, they make good bubble pipes.

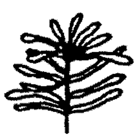
8. ASH - If the leaf looks like this, it is an Ash.



In general, ashes produce hard durable wood especially useful in making tool handles and baseball bats. The wood of the ash is desirable for campfires because it produces a hot bed of coals. At least one man says that a leaf of white ash rubbed on a mosquito bite relieves the itching at once.

NOTE: To distinguish between evergreen trees (trees with needle-like leaves) one must know:

1. PINE - needles occur in bundles.



2. FIR - needles are flat.

3. SPRUCE - needles are angular. (Hint: roll needles between fingers.) These needles also are single and do not occur in bundles.

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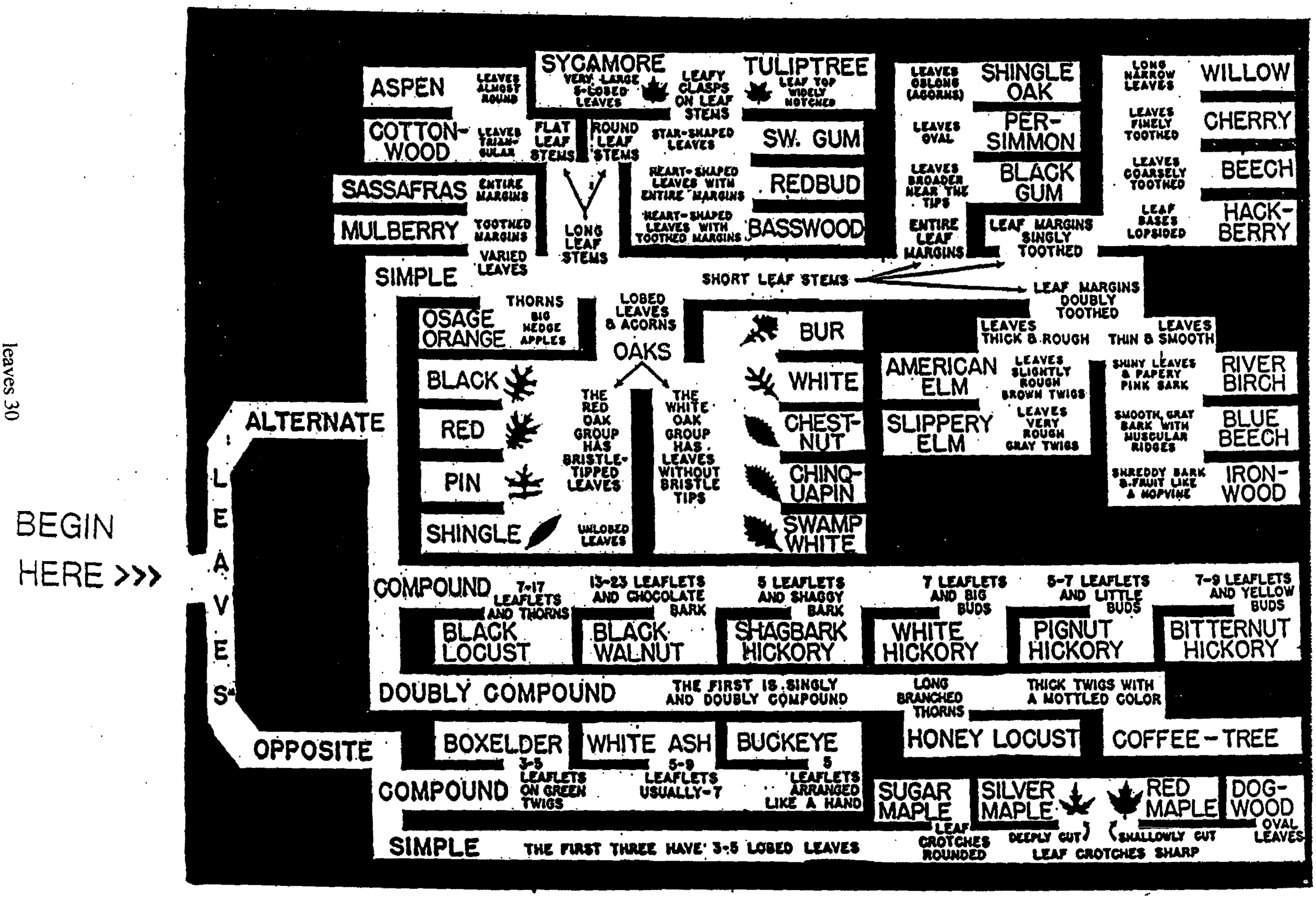
A-MAZED BY TREES? A tree identification guide



leaves 30

The leaves of oaks are variable in size, shape, lobing and the occurance of hairs. The leaves of all oaks have hairs on the under-surface when they emerge in the spring. In several species, these hairs fall off when the leaves mature; these leaves are then said to be glabrous. In other species, the hairs remain until the leaves drop in the fall. Leaves that develop in full sunlight are usually small, have long, narrow lobes, and a large number of hairs. Leaves that develop in shade, or on young seedling and sprouts are usually large, have short, broad lobes and few hairs. The following keys are based on mature leaves, developed under average light conditions, of large trees.

THE WHITE OAK GROUP

Leaves of the white oaks do not have bristle-tipped lobes or teeth. The inner surface of the acorn shell is glabrous and the scales of the cup are variable in appearance.

1. Leaves lobed, lobes 2-7 on each side, the sinuses extending more than 1/3 of the distance to the midvein - - - - - - - - - - - - - - - - - - - 2

1. Leaves coarsely toothed, teeth 7-14 on each side, sinuses do not extend 1/3 of the distance to the midvein - 4

2. Undersurface of leaves glabrous, deeply and evenly lobed, acorn 1/2 to 3/4 inch long, scales of the cup are warty; bark light gray and flaky - White Oak

2. Undersurface of leaves hairy, having a velvety touch - - - - - - - 3

3. Leaves with 2-3 pairs of lateral lobes, the central lobes may be blunt, forming a cruciform-shaped leaf; acorn 1/2 inch long with a shallow cup; bark dark gray with short blocky ridges. The leaves of this tree are extremely variable - Post Oak

3. Leaves with 4-7 pairs of lateral lobes, a pair of central sinuses usually deeper than the others, central lobes rounded or pointed; acorn 1 to 1 1/2 inches long with a deep cup, the cup is fringed with bristles; bark dark gray with long blocky ridges - - - - - - - - - - - - - - - - - - Bur Oak

4. Teeth regularly spaced and uniform; bark brown to black, deeply and coarsely furrowed; acorn 1 to 1 1/2 inches long; cup thin - Chestnut Oak

4. Teeth irregularly spaced and variable in size; bark dark brown, deeply furrowed into long scaly ridges; acorn 3/4 to 1 1/4 inches long; cup thick, bowl-shaped and slightly fringed - - - - - - -Swamp White Oak

4. Teeth equally spaced and uniform, somewhat incurved; bark light gray, breaking up into short narrow flakes; acorn 1/2 to 1 inch long, usually set in a shallow cup - - - - - - - - - - - -Chinquapin Oak

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THE RED OAK GROUP

Leaves of the red oaks have bristle-tipped lobes or teeth or the tips of entire leaves are bristle-tipped. The inner surface of the acorn shell is hairy and the scales of the cup are flat and pointed.

1. Leaves entire with a single bristle at the tip of the leaf - - Shingle Oak

1. Leaves lobed, bristles several to many - - - - - - - - - - - - 2

   2. Leaves densely hairy below: buds large, angled, hairy; bark dark, rough, inner bark orange; acorn 1/2 to 3/4 inch long; cup deep, bowl-shaped, the scales loose and hairy - - -Black Oak

   2. Leaves not densely hairy (a few hairs may persist) - - - - - 3

3. Leaves shallowly lobed; when the major lobe is folded at the base of the sinuses, the lobe rarely overlaps the sinuses on the opposite side of the leaf; acorn 3/4 to 1 1/4 inches long; cup saucer shaped; bark on upper portion of tree usually with long gray streaks- Red Oak

3. Leaves deeply lobed; when the major lateral lobe is folded at the base of the sinuses, the lobe distinctly overlaps the sinuses on the opposite side of the leaf - 4

   4. Acorn cup bowl-shaped enclosing about 1/2 of the acorn, scales relatively large, loose, and usually glossy; bark rough, blocky, brown to black below and gray above. Tree of upland slopes and well-drained areas -Scarlet Oak

   4. Acorn cup saucer-shaped enclosing 1/3 or less of the acorn, scales relatively small, tight, and not glossy; bark gray-brown smooth for many years (broken into ridges on old trees). Tree of poorly drained flats. The variations in leaf shape and form make it almost impossible to separate the leaves of pin oak and scarlet oak. - Pin Oak

1. Leaves pinnately compound. Leaflets three to five, coarsely serrate. Buds whitish pubescent, twigs often green especially on young stems. . . . . Box-elder

1. Leaves simple 2

   2. Stipules present. Leaves usually three-lobed, occasionally five-lobed, dull green above, yellowish green below. Bark on older branches black, deeply furrowed . . . . Black Maple

   2. Stipules absent 3

      3. Margins of lobes entire except for points at tips 4

         4. Leaves five-lobed, more broad than long, bright green above, shiny beneath. Petioles and young twigs with milky sap . . . Norway Maple

         4. Leaves three to five-lobed, dark green above and lighter green below, occasionally with few coarse teeth. Sinus "U" shaped . . Sugar Maple

      3. Margins of lobes regularly toothed 5

         5. Leaves lobed more than half way to midrib, deeply five-lobed, pale green above, silvery white beneath. Crushed twigs with rank odor . . . . Silver Maple

         5. Leaves lobed less than half way to midrib, sinus "V" shaped, light green above, whitish, waxy beneath. Crushed twigs without rank odor . . . . Red Maple

Tree Champs

Measure trees and hold a contest to find the biggest tree in town.

Objectives:
Explain how champion trees are determined. Define* height, circumference, *and* crown spread *and measure them on a tree.

Ages:
Intermediate and Advanced

Materials:
- ***tape measures (one per team)***
- ***paper and pencils***
- ***yardsticks (one per team)***
- ***tree field guides***

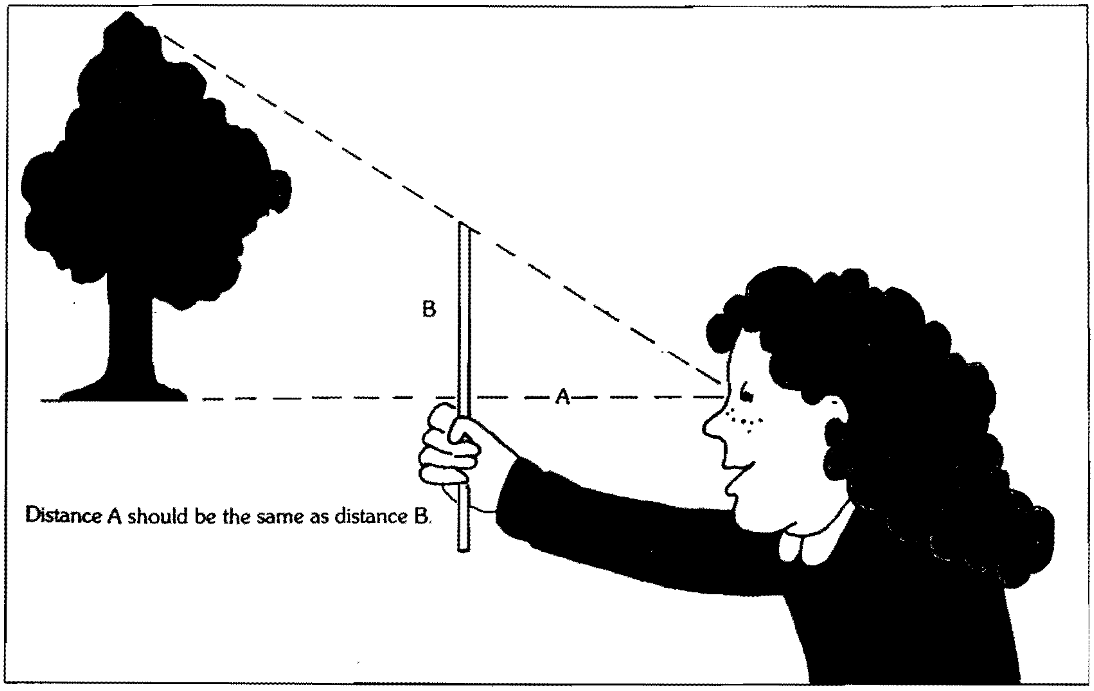
Subjects:
Science and Math

Standing 275 feet (82.5 m) high and measuring more than 80 feet (24 m) in circumference, the biggest giant sequoia in California is also the biggest tree in the United States. It is one of more than 650 "champion trees" in the nation. But even though all champion trees are considered "giants," several are less than 20 feet (6 m) high.

In this activity your kids can learn what it takes for a tree to be designated a champion. They can also learn some of the techniques used to measure trees. And afterward they'll be able to size up some trees on their own.

First explain to the kids that to be considered a champion a tree must be the biggest of its kind. A special formula is used to determine just how large a tree is. First the tree's height, circumference, and average crown spread (spread of its branches) must be measured. Then the measurements are plugged into this formula: *height* + *circumference* + ¼ *crown* = *point total.* The tree of a particular species that has the most "points" (greatest sum) is considered the champion. (If a tree comes within 5 points of the champion, the two trees are listed as co-champions. And if a tree is close, but not quite big enough to "tie" or "beat" the champion, it is put on a special list of "challenger trees.")

All of the champion trees are listed in the *National Register of Big Trees,* maintained by the American Forestry Association. And because a lot of people keep searching for bigger trees and the registered champions sometimes lose points (get struck by lightning and lose a branch, for example) the list is constantly changing.



MEASURING UP

Now tell the kids that they're going to measure some trees and then, on their own time, find the biggest tree in the neighborhood. Divide the group into teams of four and give each team a measuring tape and a yardstick. Then take the kids outside and have each team pick a tree to measure. Explain that the tree they pick does not have to be the biggest one they can find—they are measuring this first tree for practice and later will try to find the biggest one in the neighborhood. As they measure the trees, have the kids write down their measurements and then record where their tree is located and what kind of tree it is. (They can use field guides to help them identify the trees.) Here's how the kids should measure their trees:

Circumference: The circumference of a tree is the distance around its trunk. It is usually measured 4½ feet (1.4 m) from the ground and is approximated to the nearest inch (2.5 cm). To measure the circumference, have one person hold one end of the measuring tape against the tree, 4½ feet off the ground. Another child can wrap the tape around the trunk.

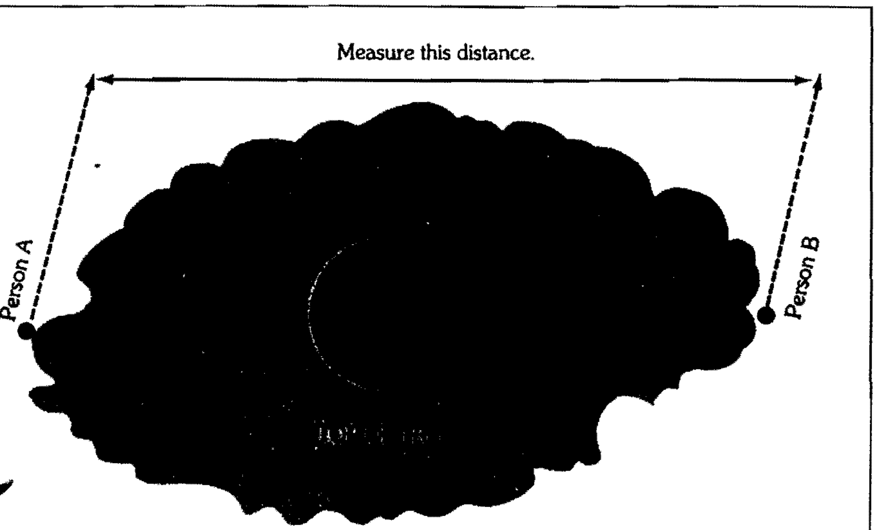
If the kids aren't tall enough to measure the circumference at 4½ feet or if there are branches at the 4½-foot mark, have them measure at the thinnest point below the mark.

Height: The height of a tree is measured from the ground to its top twig and is approximated to the nearest foot (30 cm). Have a couple of the kids in each team stay on *level* ground as they follow these directions to measure their tree's height:

1. Hold your arm out in front of you so that your fist is at eye level. (Your arm shouldn't be bent at all.) Have another team member measure the distance from your fist to your eye (see line A on diagram).
2. Face the tree you want to measure and hold a yardstick so that the distance from your hand to the top of the stick is the same as the distance you measured in step 1 (see line B on diagram). Make sure you hold the stick straight up and down and not at an angle.
3. Walk backward away from the tree until you can see the base of the tree by looking over your fist, and the top of the tree by looking over the top of the yardstick. (Don't move anything but your eyes. See diagram.)
4. When you can see the tree completely by sighting over the top of the yardstick and the top of your fist, have the other team members measure the distance between you and the tree. This distance is the approximate height of the tree. *(continued next page)*

Crown Spread: The crown spread of a tree is the distance its branches spread away from its trunk. It's approximated to the nearest foot (30 cm) and is usually taken as an average.

To measure the average crown spread of the tree first have the kids find the branch that sticks out farthest from the trunk. Have one child stand directly under its tip; then have another child go to the opposite side of the tree. He or she should stand directly under the tip of the branch that sticks out farthest on that side. Tell these two team members to take one or two steps to the side of the trunk, then have the other team members measure the distance between them (see diagram).



Now have the kids find the shortest branch of the crown. Have one child stand directly under its tip while another child goes to the opposite side of the tree and finds the shortest branch of the crown on that side. Again, have the other team members measure the distance between these two children. Finally, to get the average crown spread, have the kids add the two distances together and divide by two.

Here's some sample data you can show the kids:
Height: 60 feet
Circumference: 32 inches
Crown Spread:
widest point: 28 feet
narrowest point: 20 feet
average crown spread: 24 feet
Point total: $60 + 32 + \frac{1}{4}(24) = 98$

THE NEIGHBORHOOD CHAMP

Now that the kids can measure trees, try holding a contest to see which team can find the biggest tree around. Be sure to give the kids plenty of time to find and measure some trees on their own time, and tell them to write down where their tree is located, what kind of tree it is, and the tree's height, circumference, and crown spread measurements. They should also use the champion tree formula to find out the total number of points their trees scored. Afterward, each team can compare their "winners" to those the other teams found. Which team found the biggest tree?

As a variation, try putting together your own town register of big trees. Just give each team three different species of trees to locate and measure and have them look for the biggest specimens in the area. Then list these local champions alphabetically, writing each tree's circumference, height, average crown spread, and total points next to its name.

You might also want to find out what your state's official tree is and have the kids try to find the biggest state tree in town.

Pond Study

Objectives:
- Identify and compare measurements
- Take measurements and conduct counts
- Graph the information gathered
- Identify how aquatic plants and animals have adapted to their environments
- Discuss the links in a typical freshwater food chain

What to Teach	Teaching Suggestions
Have students prepare a "Pond in a Jar" if at all possible.	- Follow instructions under "Pond in a Jar." Materials can be gathered easily at local ponds or lakes. - Students should keep records and counts on what occurs in the jars as they progress.
Do follow-up studies with the pond microcosm.	- This activity could be turned into a science fair experiment or long-term project by testing different lighting conditions, seeing the first-hand the effects of pollution on aquatic organisms, and experimenting to see what different pond sites contain when "grown."
Discuss with students what lives in and around a pond. Show pictures if available.	- Most students will be able to name The mammals, birds, and herptiles (ie. raccoon, muskrat, beaver, snapping and painted turtle, snakes, frogs, Canada geese, mallards, blue herons, etc.) - Ohio ponds also contain channel catfish, bullhead catfish, largemouth bass, smallmouth bass, bluegill, various sunfish, and crappie. - Various plant species love to grow around or in water, including cattails, willows, arrowheads, and pondweed. Background information: "Aquatic Plants."

What to Teach	Teaching Suggestions
	- Many insects have an aquatic stage in which their larvae can be found in the pond water or the mud of a pond bottom.
Have students complete the activity "Living Together" before, during, or after the discussion of pond organisms.	- This activity breaks the organisms up into vertebrates and invertebrates. Hopefully this will help students categorize what will be found in a pond.
Discuss the various insects and insect larvae that can be found in a pond.	- Refer to "Common Pond Animals" for pictures of the insects and "Aquatic Bugs" and "Aquatic Insect Believe It or Not" for general information. Also see the stream study section for different information and pictures.
Q: Why are aquatic insects and insect larvae important in a pond?	A: These insects and other invertebrates are an important source of food for many other pond organisms, especially for fish. Fish are in turn food for water birds and humans.
Introduce the concept of a food chain or web. Discuss the terms associated with food chains. food chain – a sequence of organisms in a community in which each member feeds on the one below it. food web – a network of organisms in a community who rely on each other in interconnected ways for food. Each organism feeds on numerous other organisms.	- See the activity titled "A Biological Community." This introduces the Terms producer, consumer, and decomposer. Also see "The Living Pyramid" for a different approach, using a grassland community as the basis.

* Included in this lesson are numerous different types of food chains or webs ("Aquatic Food Chain" and "An Ohio Food Chain"). Use those that you find the most convenient and the most understandable to the class.

What to Teach	Teaching Suggestions
Emphasize the complexity and importance of food chains and webs. Make sure students are aware that all organisms rely on all other organisms in one way or the other.	- Have the class so the activity "Webbing." Follow through with the suggestions to show how the entire Ecosystem is affected when just one organism is affected, either by pollution, over-harvesting, natural disaster, or human impact.
Prepare for the trip to Sharon Woods	- Read through "The Aquatic Safari" to understand what will occur. Students will need to be prepared to get muddy and wet.
Maintain a record of organisms found	- Use the "Checklist of Common Aquatic Invertebrates" to record the numbers and types of invertebrates found in Schrock Lake. Keep the records so the numbers can be compared to what is found during the stream study.
Visit Sharon Woods Metro Park.	**- The naturalist will lead students on a hands-on exploration of Schrock Lake, an 11-acre pond in Sharon Woods. Students will observe first-hand many of the organisms present in the pond by netting them. The naturalist will discuss with students how many of the aquatic organisms have adapted to their life in the pond. Also, the importance of the food chain in this average body of freshwater will be discussed.**
Discuss what was found	- Students can write about what they learned or "Create a Scene" to portray what they saw. The images on the copycat page can be used if needed.

What to Teach	Teaching Suggestions
Review the concept of food chains and webs.	- Now that students know first-hand what is found in a pond, do the activity "Weaving the Web".
Graph the type and number of organisms found.	- Have students use various types of graphs to graph the counts of organisms made in Schrock Lake.
Q: Which types of organism were most abundant? Which were least abundant? Why?	- There are various reasons why, such as where the organisms were being caught. Some organisms prefer deeper, colder water. Also, the organisms may be higher on the food chain. To keep a balance, there are usually fewer of those organisms who are higher on the food chain. The time of the year also has an effect on the number and type caught.

How-To-Do-It

Pond in a Jar

David W. Allard

I have found microcosm laboratory exercises to be quite successful with my students, especially in introductory biology and environmental biology courses. Initially described by Taub (1969) as a means for observing and manipulating single natural phenomena, simulations allow students to investigate important principles of ecology such as succession, predator-prey relationships, population dynamics, and the effects of manipulating various environmental factors, in a laboratory situation. Investigations with microcosms are also becoming an important area of sophisticated research in modern ecology (Odum & Deyers 1992). There is a growing body of research literature using microcosm techniques (e.g. Larsen et al. 1986 and Taylor et al. 1990). Ecologists are using very elaborate microcosms to simulate natural environments (Adey 1992). The studies are limited in that whole ecosystem responses cannot be observed, but still provide valuable insights into ecosystem processes. These techniques are also being used in the classroom (Corner 1992; Jones 1992; and Murphy et al. 1992) to give students hands-on experiences.

I have tried a number of different types of microcosms, such as hay infusions and bottle biology projects. One of the most successful activities is what I call a "pond in a jar." I modified this activity from Taylor and Kaufman (unpublished). It is an easy way to set up a self-sustaining ecosystem and it is very versatile. The simple and inexpensive exercise works for students at almost any level, elementary school to graduate school. It can be used as a simple observation activity or to perform a variety of experiments. Field trips can be combined with a long-term indoor activity or the "pond in a jar" can be a substitute when field trips are impractical.

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Materials

The following materials are needed to assemble the microcosm:

- Glass or plastic wide-mouthed quart jar (Jars with plastic lids work best as they do not rust; bigger jars are okay, but smaller sizes do not work very well).
- Plankton nets (I use commercial plankton nets, but handmade nets of stocking or other material could substitute).
- Water samplers (I use a Van Dorn Sampler, but homemade equipment could substitute).
- Small hand trowel.
- Bottom sampler (I use a Peterson Dredge, but a shovel will suffice if that is all that is available).
- A light setup or a well-lighted window.

Procedure

I take my classes on a field trip to a local park that has a pond in it; however, if field trips are impossible, the instructor can do the collecting and bring the materials to campus. The students then assemble their microcosms in the classroom. I have my students bring their own jar and I supply the sampling equipment. I teach the students how to use the various samplers. Students then prepare their "pond in a jar."

Preparing the Microcosm

- Take a sample of bottom mud with the dredge.
- Place an inch or two of mud in the bottom of the jar (There should be some benthic organisms in this mud).
- Take plankton samples and add them to the jar (This provides a nice group of microcrustaceans—cladocerans, copepods, etc.—and algae).
- Place some sticks, rooted aquatic plants, filamentous algae, duckweed, etc. into the jar.
- Fill the jar up with pond water and cap it.
- Return the jars to the lab for further observation and experimentation.

It is not a good idea to place larger organisms, such as fish and insects, in the jar. I have had students ignore this and place small minnows in their jars. The minnows have survived an entire semester. The jar should be kept closed. The ecosystem will remain functioning for a very long period, given adequate light. I have a light setup and keep the jars under fluorescent lights. The lights are on a timer and stay on 14 hours per day. These ecosystems can be stored in the dark and brought out at a later time. They rejuvenate when placed in light.

Investigations

Students may pursue a variety of investigations using their microcosms. The following is a list of some of the possibilities.

- Measuring pH and other physicochemical parameters over time.
- Successional studies done by keeping records on the organisms they find in their jars over time. My students have found leeches, hydra, amphipods, copepods, cladocerans, ostracods, midge larvae, various types of algae, snails, etc.
- Controlled investigations using paired jars (experimental and control) to determine the effects of:

1. Different lighting conditions
2. Fertilization with inorganic nutrients
3. Organic enrichment, such as adding sucrose
4. Inorganic and organic pollution.

pond 5

Conclusion

The "pond in a jar" is a simple and inexpensive way to bring ecology into the classroom. It is very versatile and can be adapted for life science courses at all levels.

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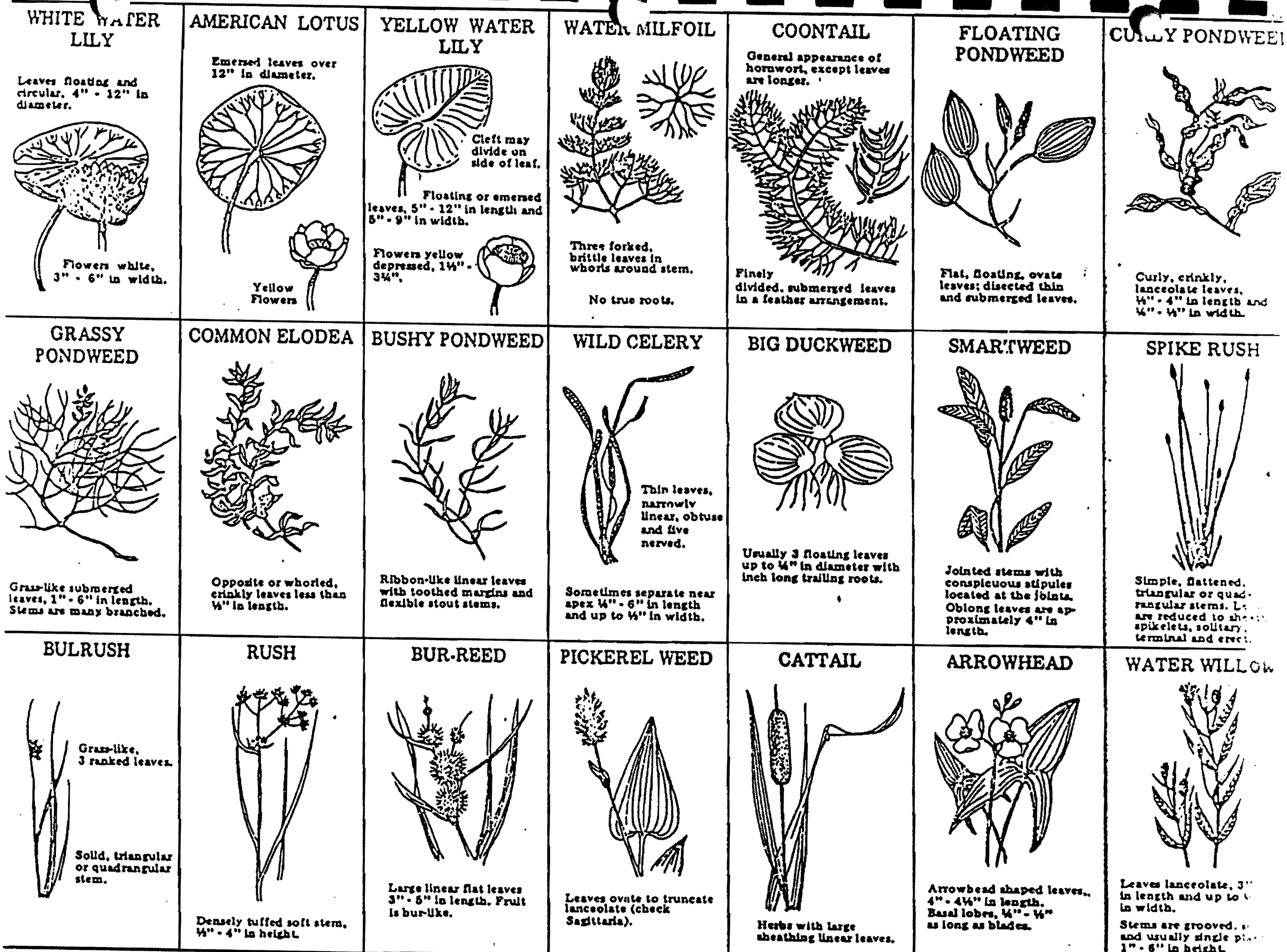
pond 7

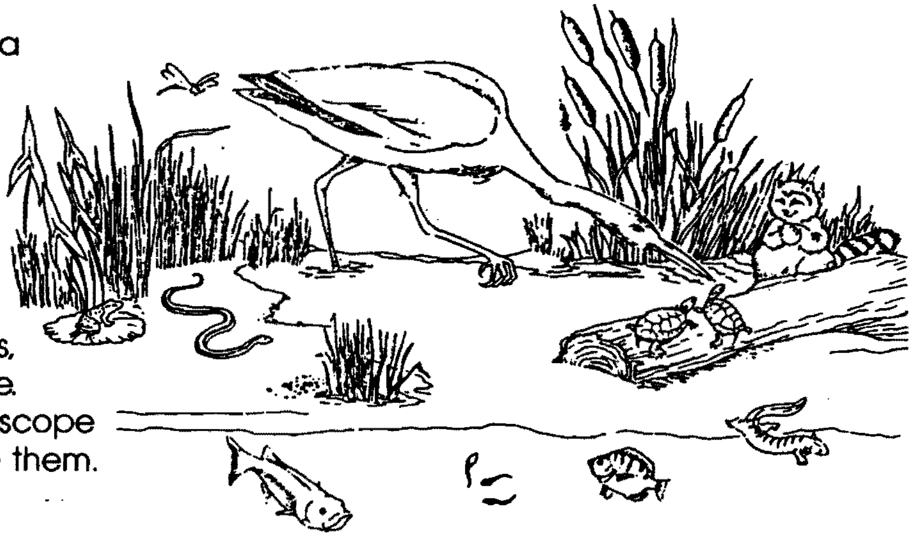


AQUATIC PLANTS

Living Together

Name ____________________

A pond is an important habitat for a variety of different kinds of animals. Many of these animals make their residence in or around the pond while others visit the pond to find food and water. Many of these animals can be easily seen in or around the pond. Others, such as the different kinds of aquatic insects, are very small and difficult to locate. Still others are so small that a microscope is needed to discover and examine them.



Locate as many different kinds of animals that can be found in the pond community. List them in the correct category.

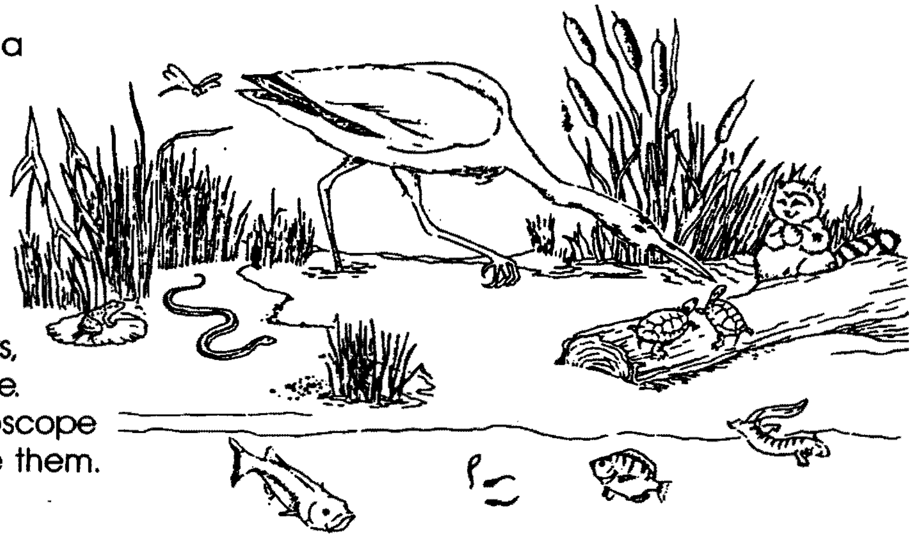
VERTEBRATES				
MAMMALS	**BIRDS**	**AMPHIBIANS**	**REPTILES**	**FISH**

INVERTEBRATES		
INSECTS	**AQUATIC INSECTS**	**OTHER INVERTEBRATES**

Living Together

Name KEY

A pond is an important habitat for a variety of different kinds of animals. Many of these animals make their residence in or around the pond while others visit the pond to find food and water. Many of these animals can be easily seen in or around the pond. Others, such as the different kinds of aquatic insects, are very small and difficult to locate. Still others are so small that a microscope is needed to discover and examine them.

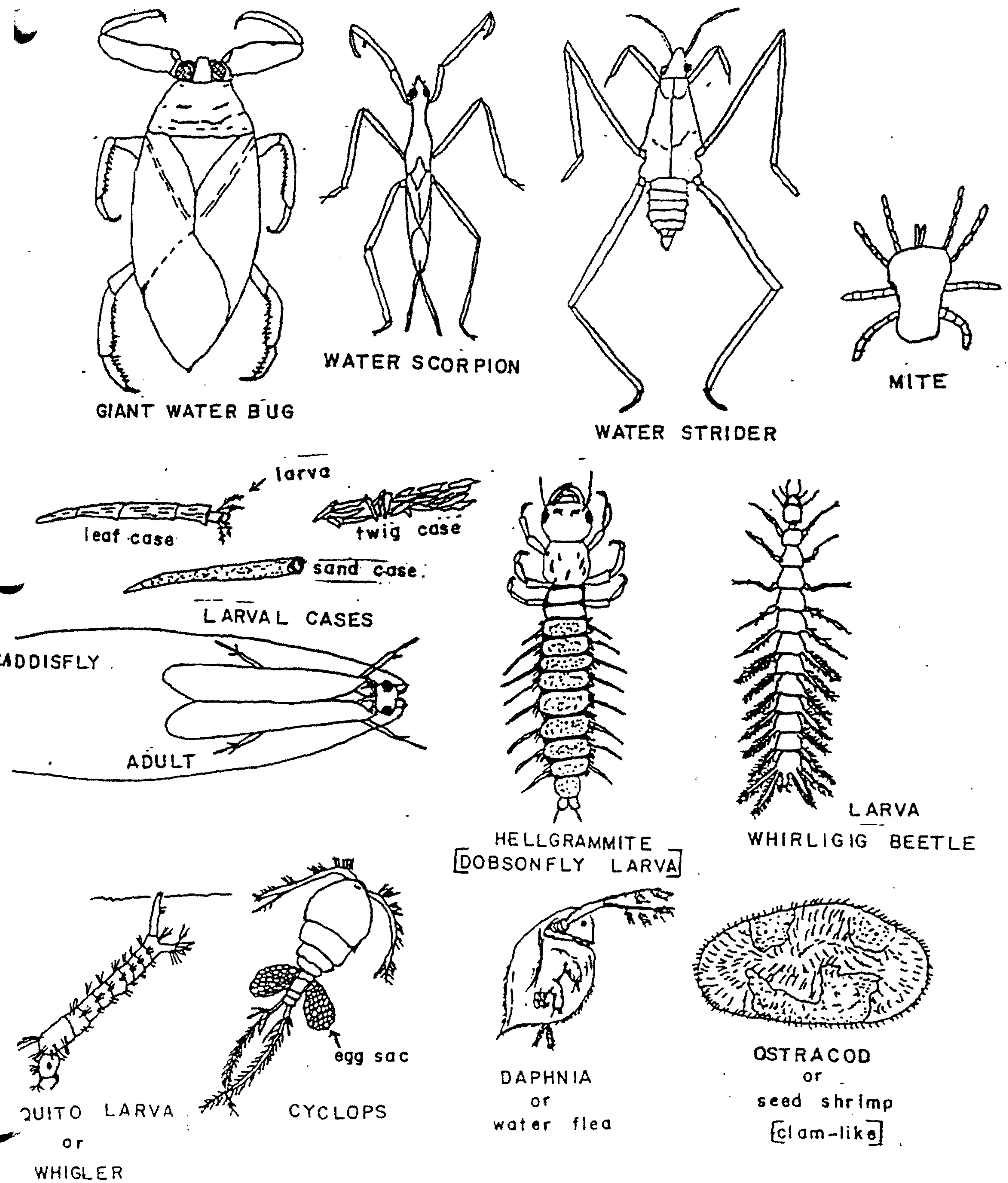


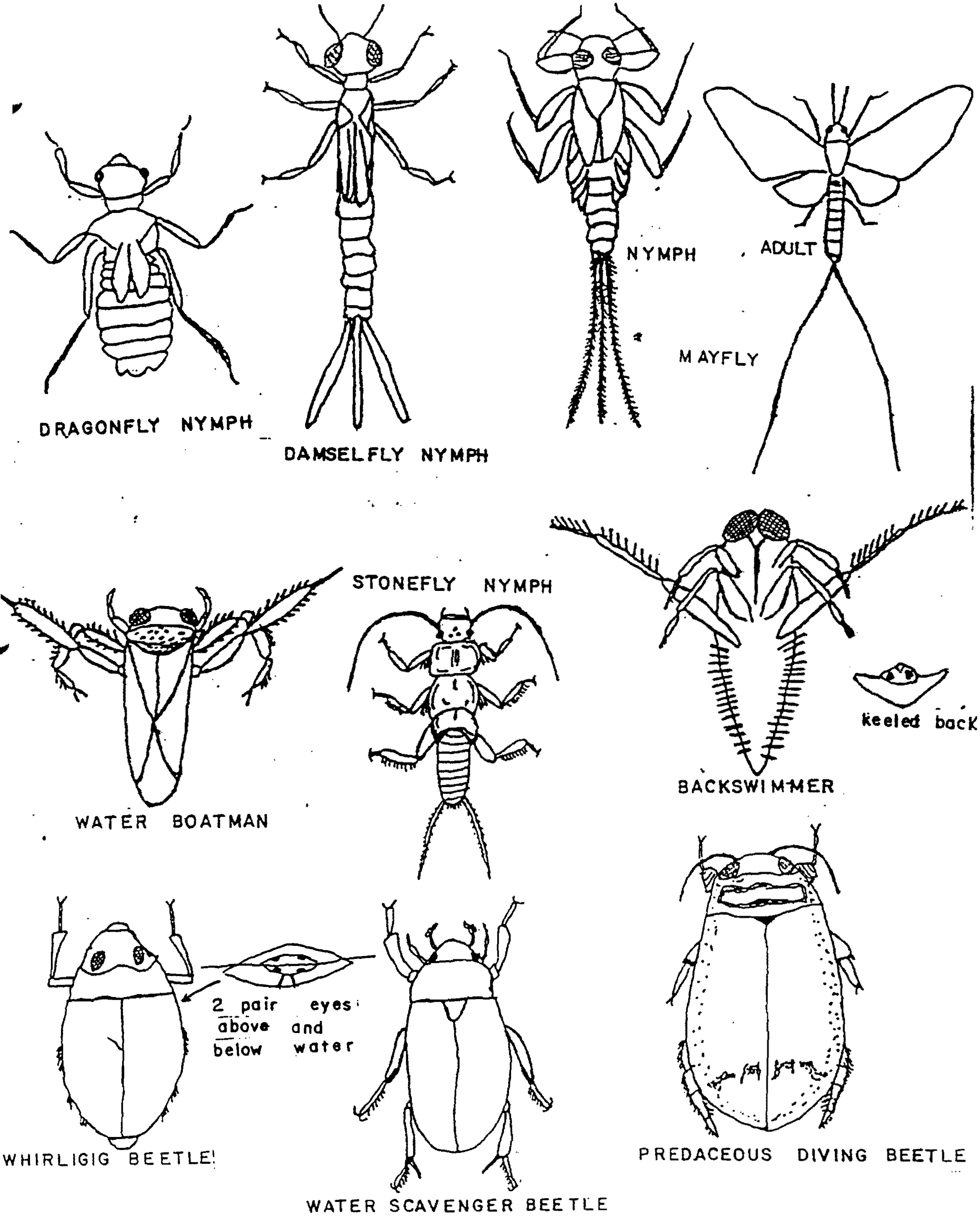
Locate as many different kinds of animals that can be found in the pond community. List them in the correct category.

VERTEBRATES				
MAMMALS	**BIRDS**	**AMPHIBIANS**	**REPTILES**	**FISH**
raccoon	mallard	green frog	garter snake	bluegill
beaver	blue heron	Amer. toad	water snake	sunfish
muskrat	Canada goose	salamander	painted turtle	bass
			snapping turtle	crappie
				catfish

INVERTEBRATES		
INSECTS	**AQUATIC INSECTS**	**OTHER INVERTEBRATES**
mosquito	water strider	snails
dragon fly	water boatman	crayfish
damselfly	backswimmer	clams
	insect larvae	

COMMON POND ANIMALS




DRAGONFLY NYMPH
DAMSELFLY NYMPH
NYMPH
ADULT
MAYFLY
STONEFLY NYMPH
WATER BOATMAN
BACKSWIMMER
keeled back
2 pair eyes above and below water
WHIRLIGIG BEETLE
WATER SCAVENGER BEETLE
PREDACEOUS DIVING BEETLE

NOT TO SCALE

AQUATIC BUGS

Water Scorpions secretive and sluggish, large eyes, long respiratory tube held up to surface for breathing, lie in wait for food, eggs laid on stems and leaves of submerged plants, 1/8" apart in straight rows

Ranatra 20-40mm, extremely long and cylindrical

Nepa 17mm, broader and flatter, 1/3 as wide as long

Giant Water Bugs large bugs (2070mm), ponds and quiet pools, rest on bottom or sit on plants with tip of the abdomen projecting through the water's surface. Flat oval bodies, brown or dull green, front legs held outward (raptorial pose), hind legs flattened and fringed, abdomen breaks the surface, air fills the tracheal system, bubble forms. Eat crustaceans, tadpoles, frogs and fish several times their size, toe-biters (sting with toxic substance). Eggs cemented to back of male for a week until hatched or are attached to submerged plant stems. They are attracted to and hit electric lights, will chirp when held in your hand, eject an apple-smelling fluid, may "play dead"

Creeping Water Bugs half creep, half swim over dense vegetation in quiet waters, broad flat and long, fiercely predacious, raptorial forelegs, eggs laid in shallow water.

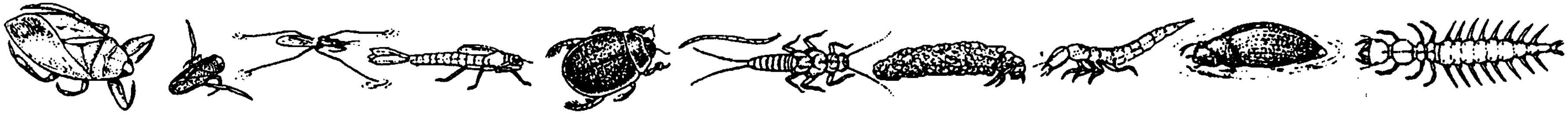
Pigmy Backswimmers small (1.5-2.5mm) deeply arched, gray-yellow bodies, clinging to dense mats of stoneworts and water milfoil, swim only short distances, even rapid strokes, eggs laid on plant stems.

Backswimmers various colors, large eyes often red, powerful oarlike strokes for short distances then rest by clinging to plants with swimming legs outstretched, rise to surface to lie belly-up with tip of abdomen breaking the surface, hind legs long and fringed for swimming, front legs short and raptorial, predators attacking even small fish, eggs laid in spring and summer on stems or stones or inserted into stems, more thatn one brood per year, 4-segmented antennae.

Water Boatman very common in shallow water, fly into lights at night, large eyes, flattened bodies, dary gray, often mottled and cross-lined with yellow, middle legs are very long, hind legs flattened and fringed for swimming, can stay submerged for long periods by holding air under their forewings as well as in a film over the body, eat protists, mosquito larvae, plant debris, green algae filaments, scent glands, eaten in turn by fish

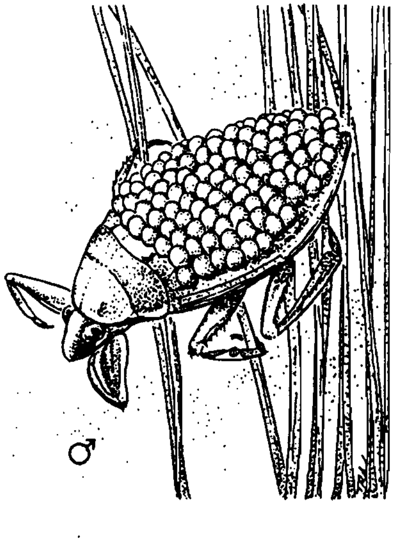
Marsh Treaders resemble walking sticks, long elbowed antennae, brown to green body, long slender legs, walks slowing across floating plants and debris, sharp claws will break through the water's surface, eat small animals by spearing with long beak, no scent glands, eaten by fish, long stalked eggs are laid on plants near water's surface

Water Striders live on the water's surface, their tarsal claws are set well back from the tips of the legs so they do not break the water's surface film, seize any prey that falls into the water and catching crustaceans and small aquatic insects that approach from below, eggs laid in spring and summer in long parallel rows glued to floating objects.

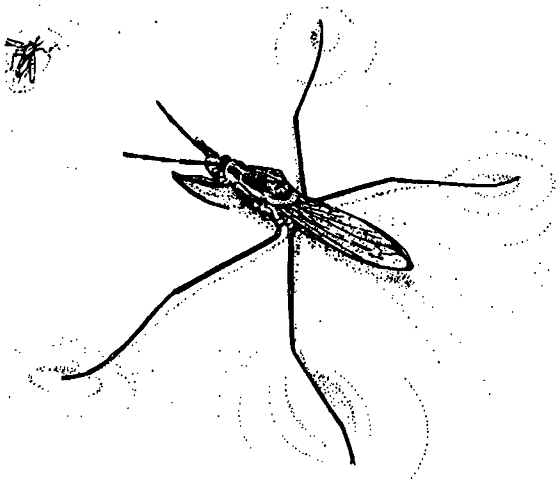


Aquatic Insect Believe It or Not

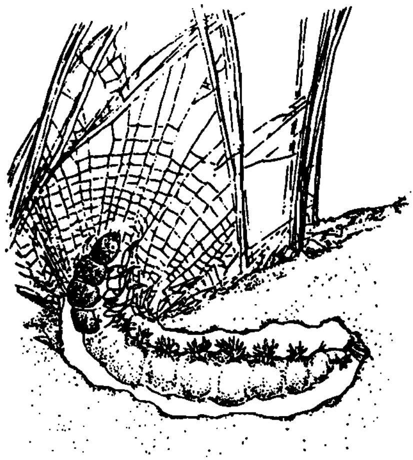
- Whirligig beetle adults zip around the water's surface at speeds of up to 3 feet (1 meter) per second. This means that the whirligig beetle can propel itself a *thousand* times its body length in just the blink of an eye.
- The eggs of the giant water bug are carried on the back of the adult male—not the female.



- Water striders locate prey, as well as mates, by sensing vibrations on the water's surface through their feet.



- Dragonfly adults are capable of bursts of speed in the air of up to 75 miles (120 km) per hour.
- Some caddisfly larvae spin silk to make their own underwater net houses. To ward off intruders, they rub their forelegs against their head to create threatening sound vibrations.

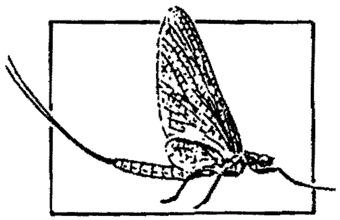


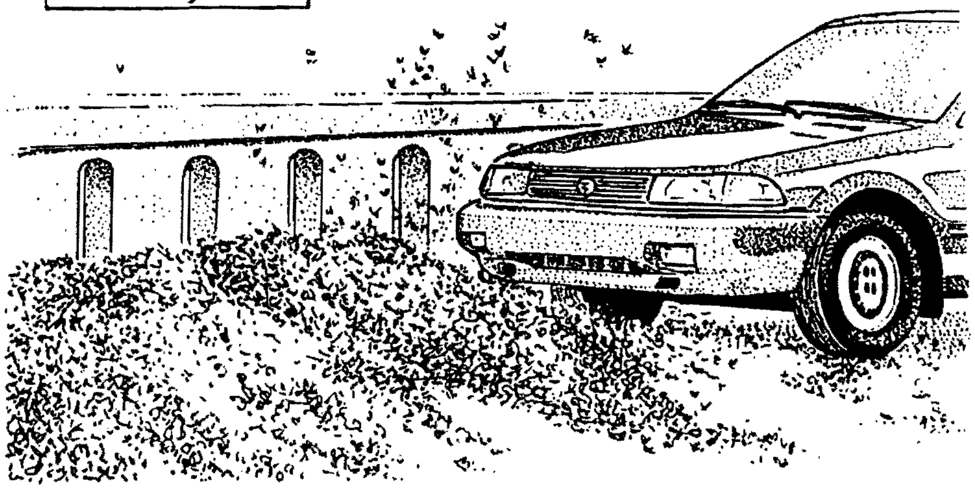
Caddisfly larva (family Hydropsychidae)

- Dragonflies have changed very little since the Carboniferous Period 300 million years ago—except for one big difference. The wingspan of prehistoric dragonflies sometimes exceeded 3 feet (1 meter)! Today the largest dragonflies have wingspans of about 4 inches (10 cm).
- Different species of stonefly nymphs change into adults year-round. If you see an insect flying around on a cold winter's day or crawling on snow or ice, it is probably a stonefly.
- The whirligig beetle is a fascinating insect, most often found in ponds and in the still areas of streams. The shiny black adult whirligigs congregate in groups, spinning around each other like bumper cars. If disturbed, they scatter in every direction and then recongregate. Adults are almost always found on the surface of water. Whirligig beetles have two pairs of eyes, one pair above the water and one pair below. The adults use their below-water eyes to hunt for small prey.

- Giant water bugs inject enzymes into their prey, which dissolve the internal body parts of their victims. Then they suck out the liquefied insides. In this way, a giant water bug can ingest prey many times its size, such as frogs and young fish.

- When some species of mayfly nymphs change into adults, they live only two hours. Mayfly adults do not even have working mouthparts, so they can't eat. All they do is mate and lay eggs. Mayfly nymphs somehow know when other nearby mayflies of their species are changing into adults and they change too. As a result, thousands of mayflies are ready to mate at the same time before they die. At certain times of the year, some small bridges over streams have become so cluttered with dead mayflies that snowplows have had to clear them.

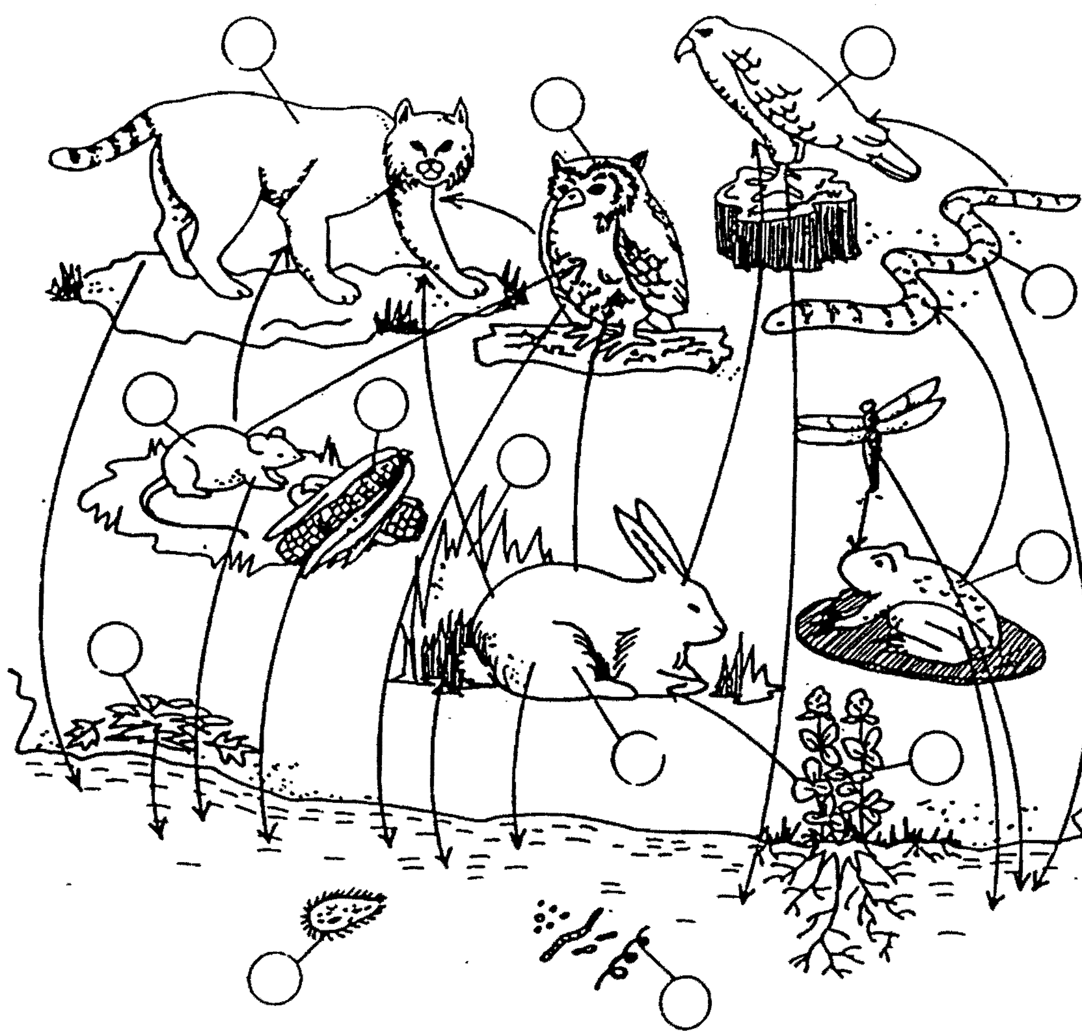




Mayflies **(Hexagenia)** *after mass emergence from a stream*

A Biological Community

No one organism can exist by itself; all living things in one way or another depend on each other for food. The living things or organisms which live together in a particular place are referred to as a biological community—a desert, lake, pond, field or sea can be a biological community. As one organism eats another, energy is transferred. The passing of energy can be illustrated in the food web below.



In the above drawing of a food web, put the number of the member of the community described below in the circle on the drawing which it represents.

1. Producer—only green plants can be considered producers because only they have the ability to make food

2. First level consumer—a living thing that feeds directly on green plants

3. Second level consumer—a living thing that eats mostly first level consumers

4. Third level consumer—a living thing that eats mostly second level consumers

5. Decomposer—an organism that breaks down the remains of dead plants and animals, releasing energy that can be recycled into the food web

Key

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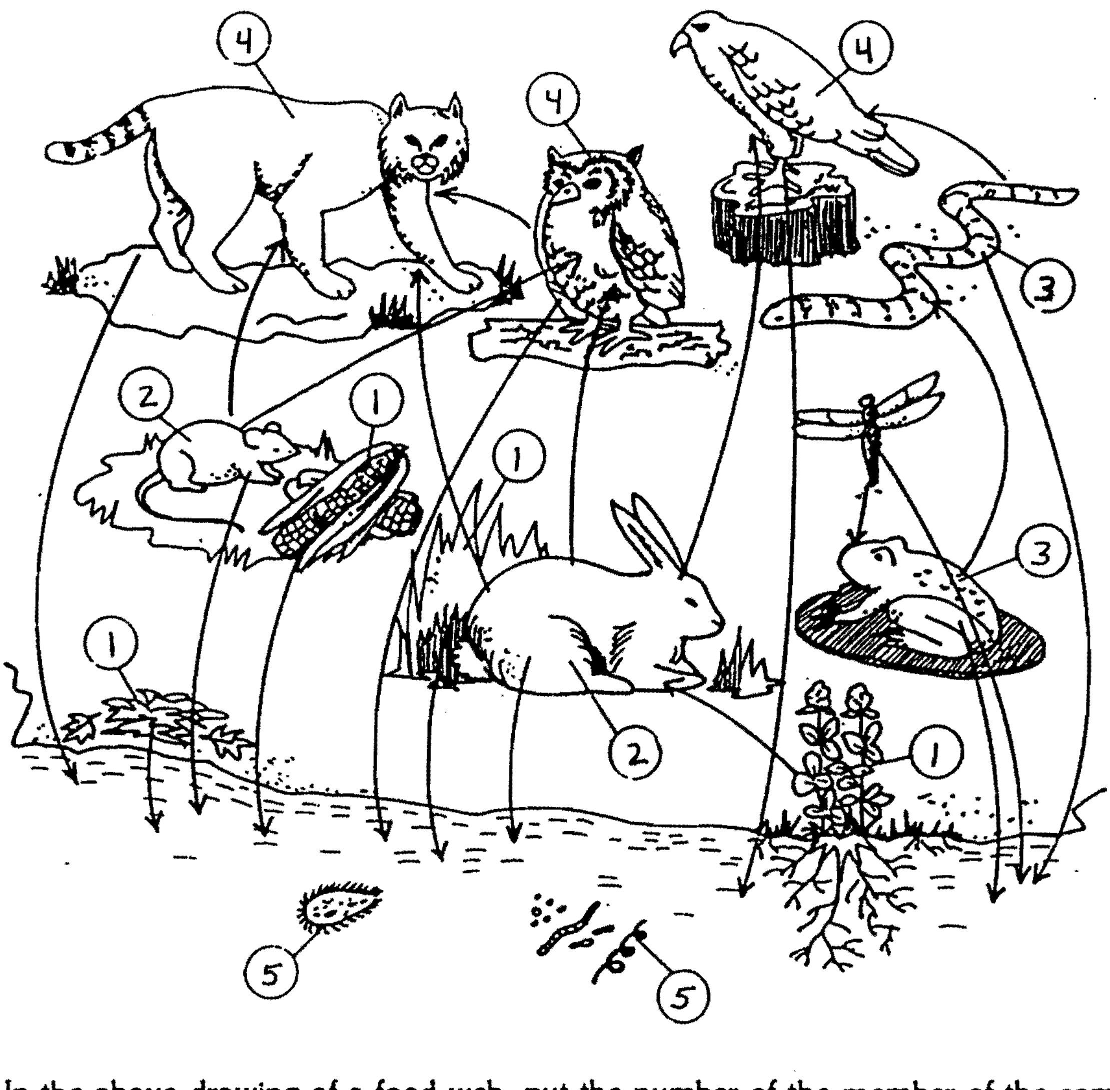

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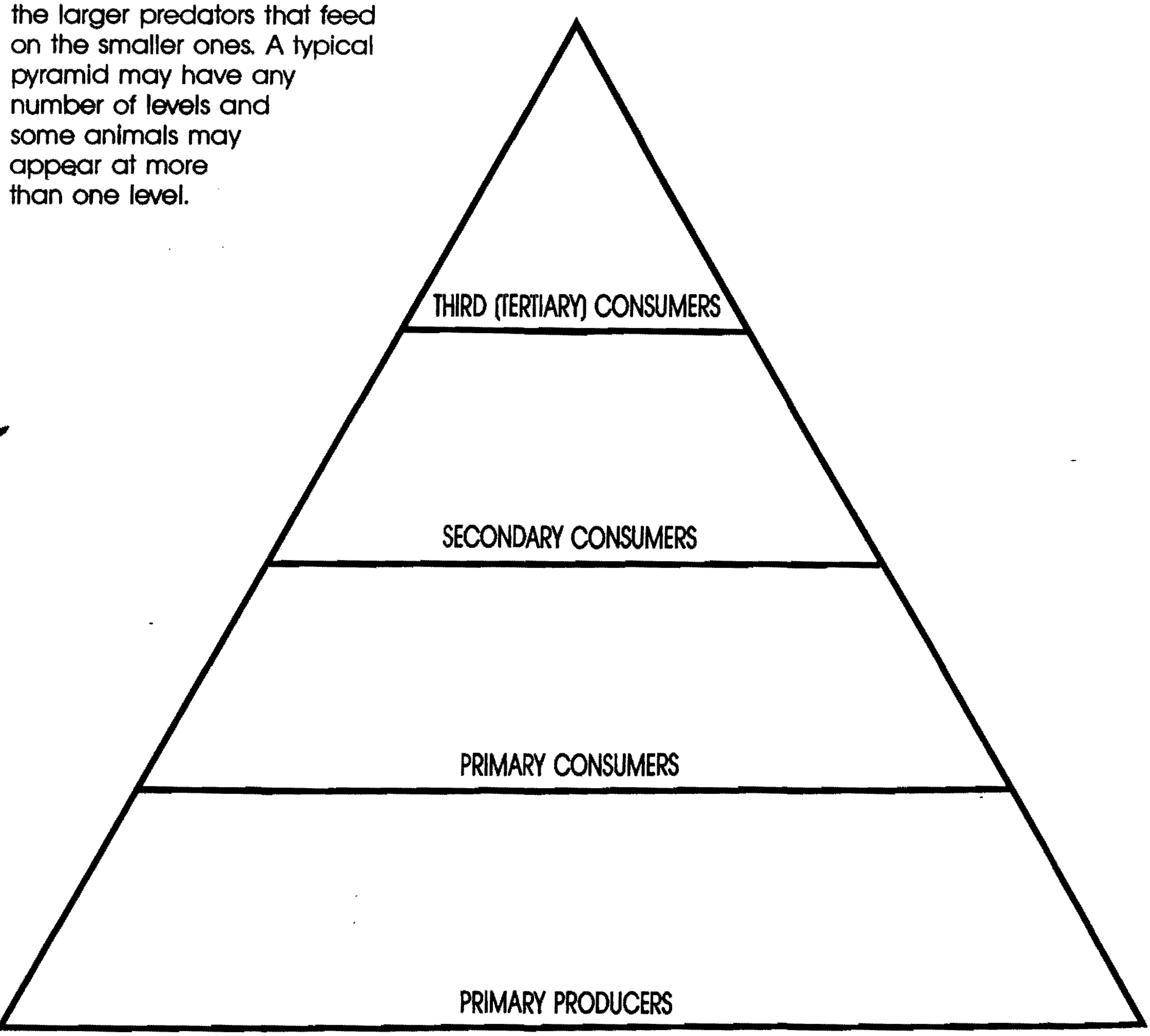
The Living Pyramid

Name ____________________

Biologists sometimes look at living things from a particular community as forming a pyramid. Food energy is passed upward through the pyramid from lower-order consumers to higher-order consumers. At the bottom level are the primary producers which are usually a variety of plants. At the next level are the primary consumers, that is, the animals that eat plants. The next level are the secondary consumers - small predators that eat the plant-eaters. At the upper levels of the pyramid are the larger predators that feed on the smaller ones. A typical pyramid may have any number of levels and some animals may appear at more than one level.



Study the different kinds of animals that are pictured on the Grassland Community poster. Write the names of animals on the energy pyramid pictured above. Some animals may be listed on more than one level.

The Living Pyramid

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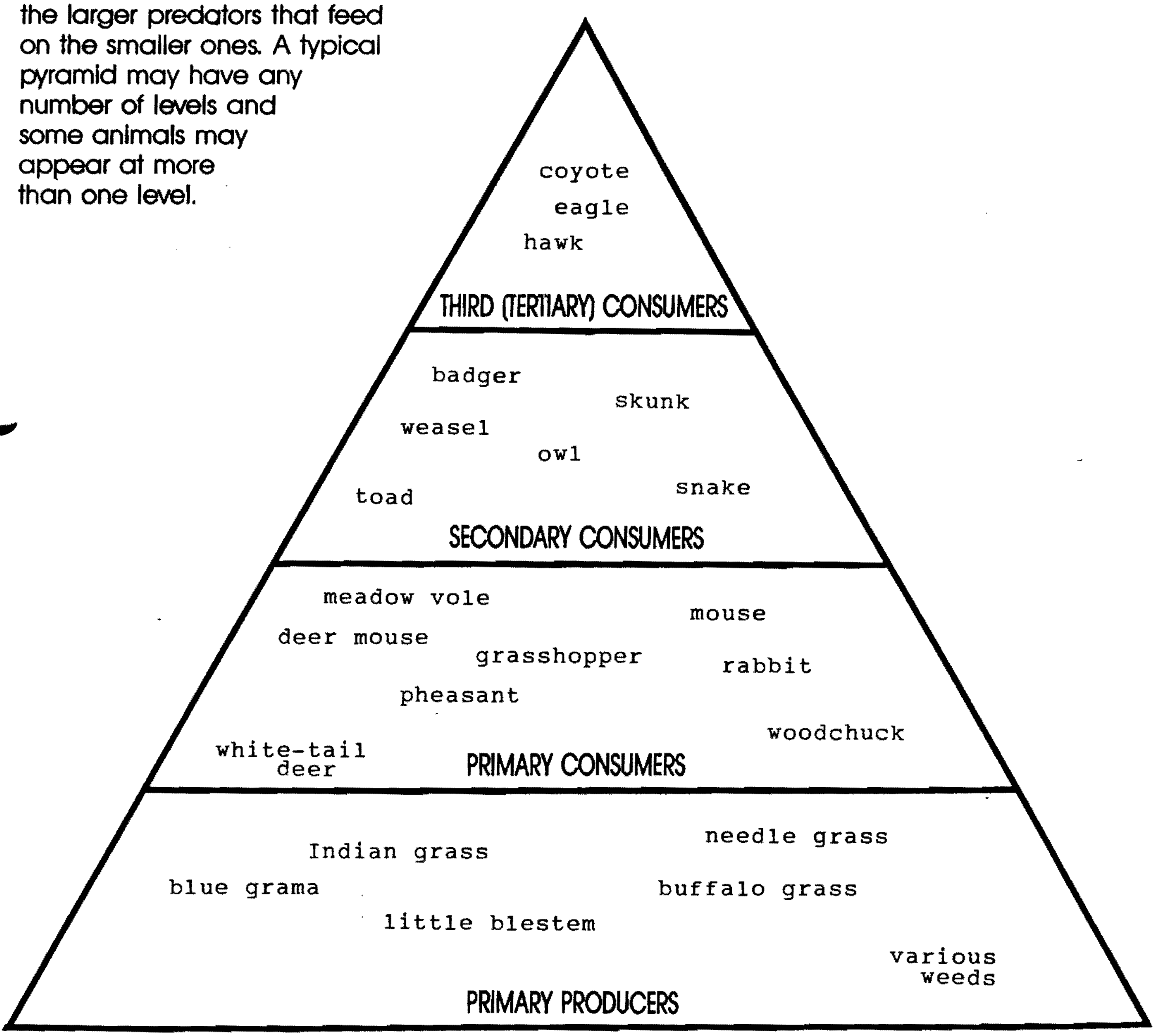

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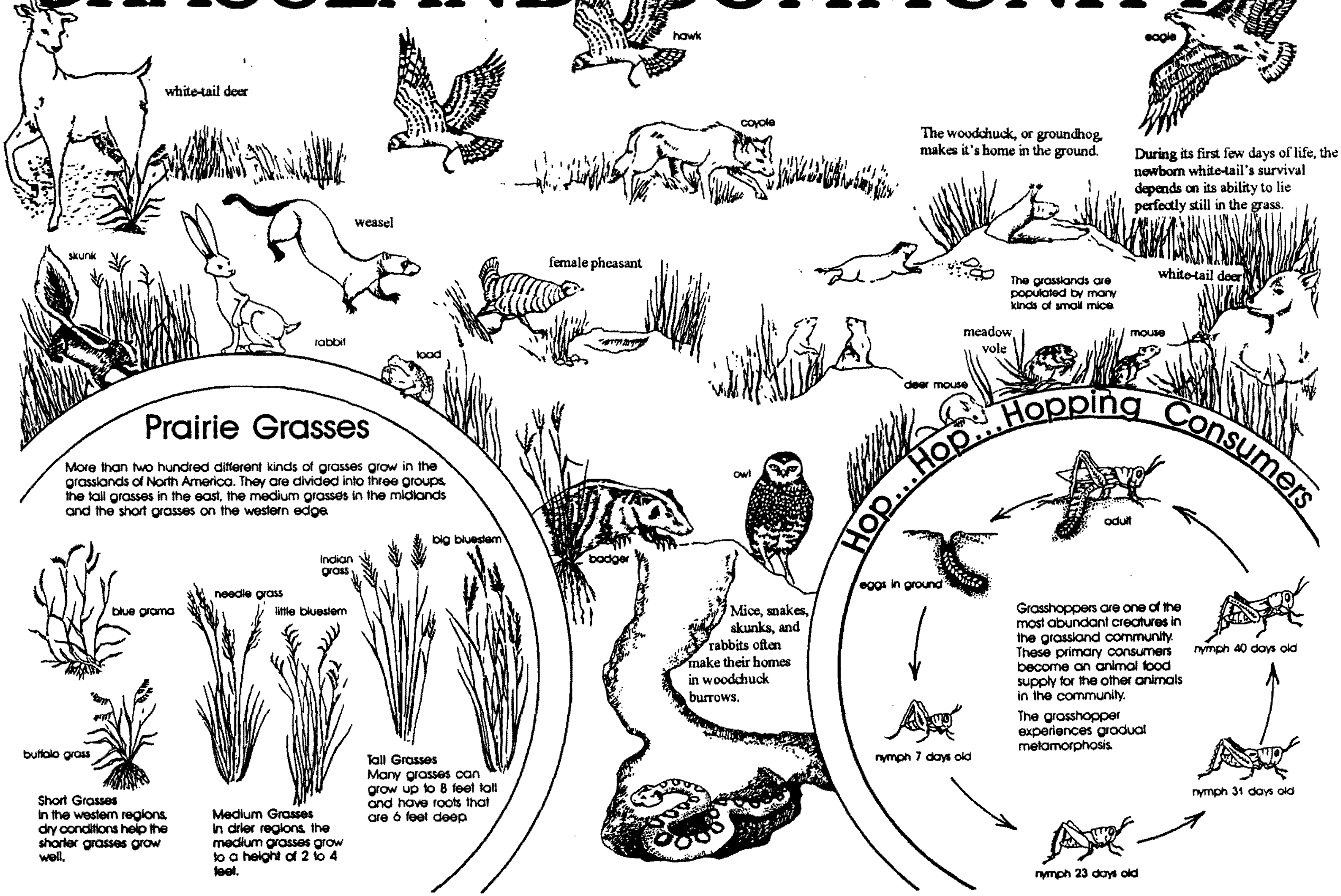
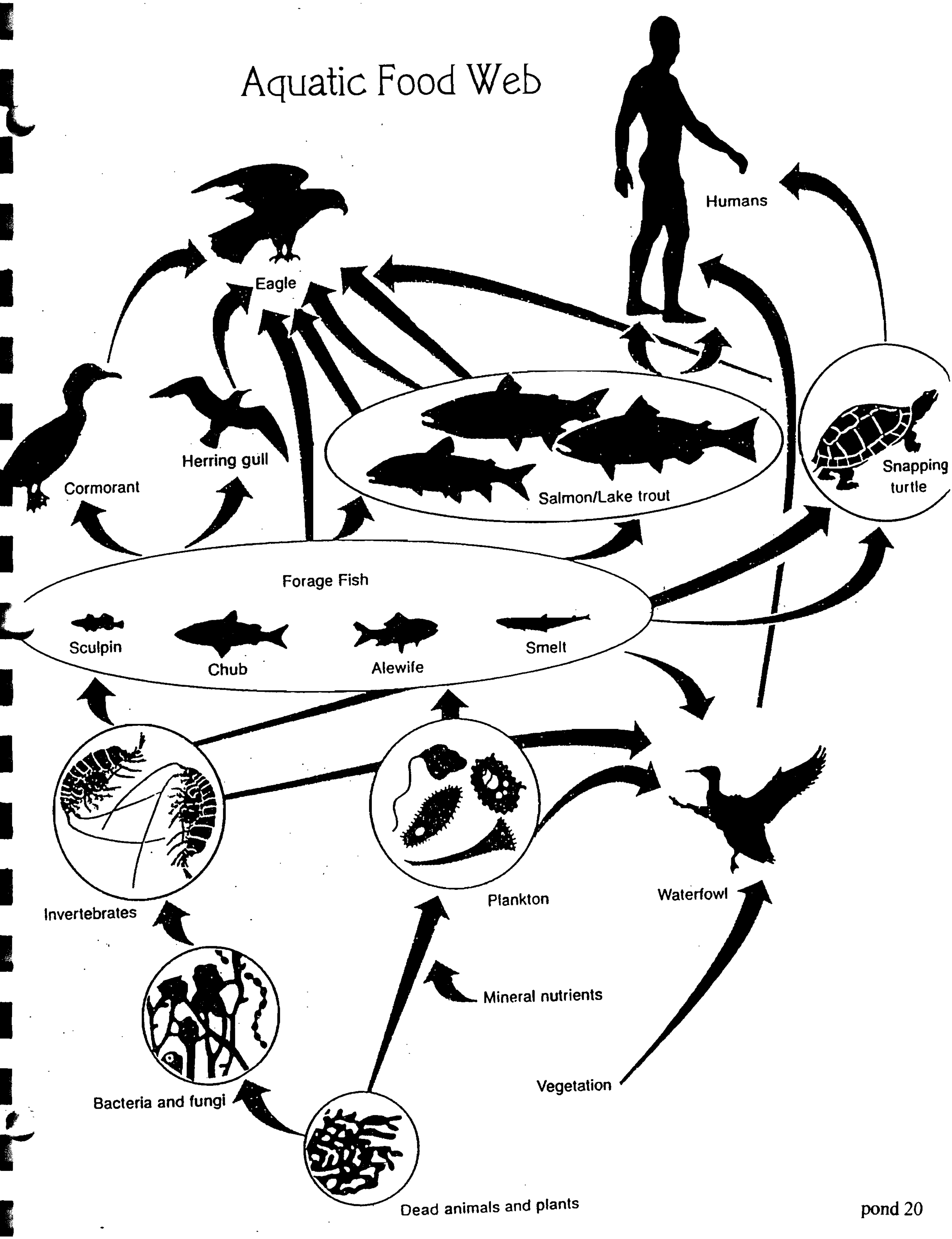
GRASSLAND COMMUNITY

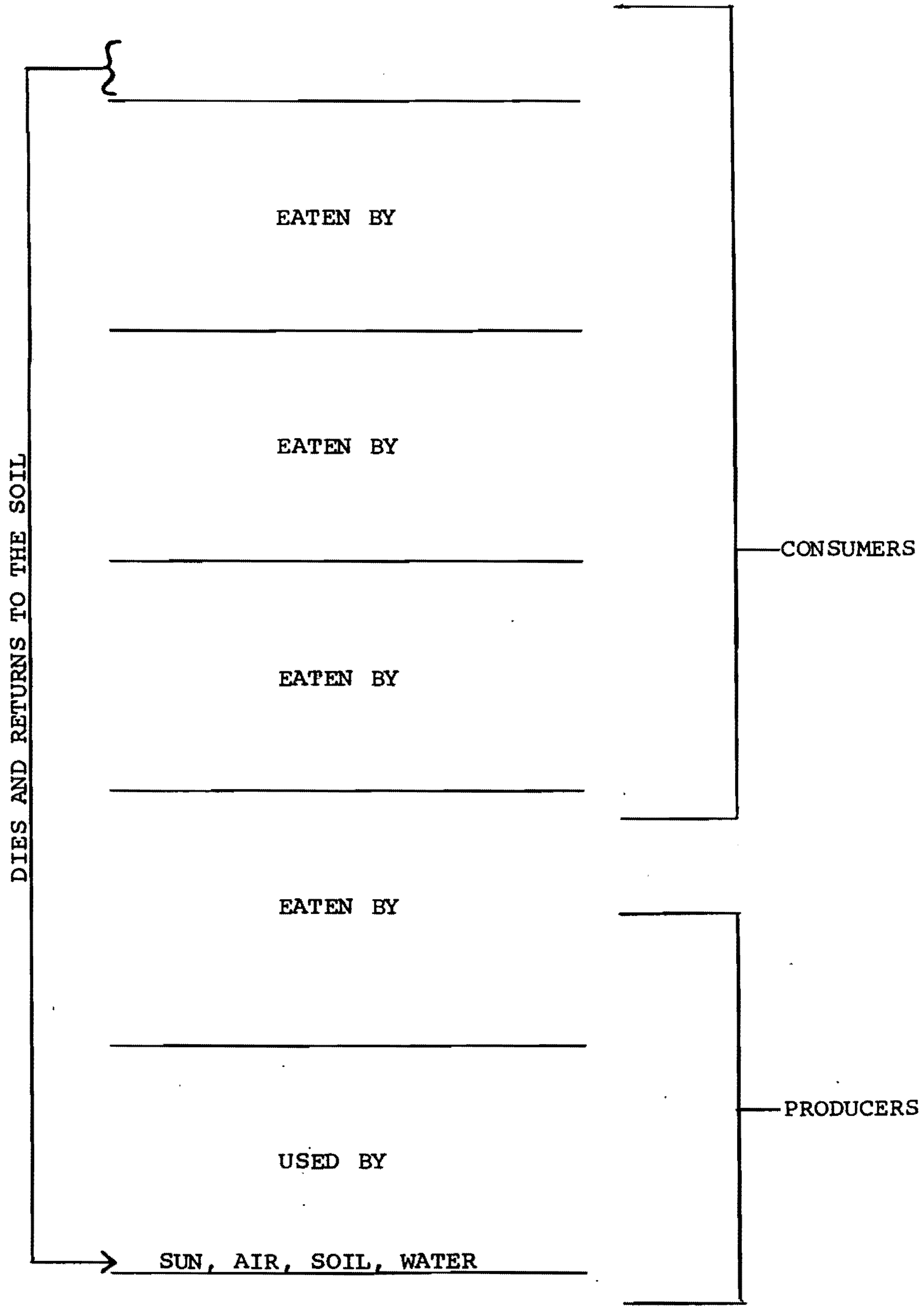


Aquatic Food Web



An Ohio Food Chain

Fill in the blanks below to create a food chain that might exist in Ohio today.



An Ohio Food Chain

Fill in the blanks below to create a food chain that might exist in Ohio today.

red-tailed hawk

EATEN BY

water snake

EATEN BY

green frog

EATEN BY

grasshopper

EATEN BY

corn plant

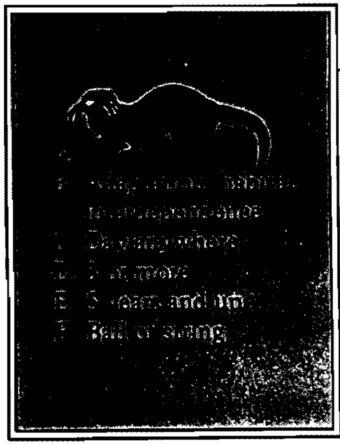
USED BY

SUN, AIR, SOIL, WATER

DIES AND RETURNS TO THE SOIL

CONSUMERS

PRODUCERS



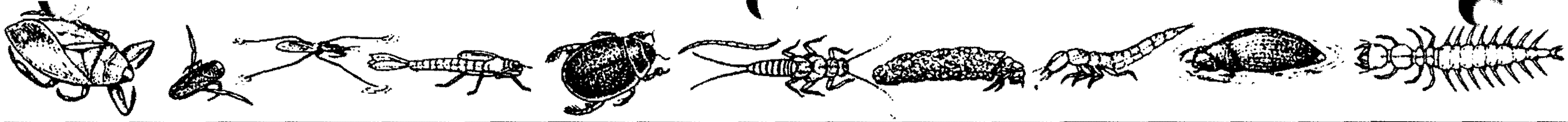
Webbing

HERE IS A GAME that makes very clear the essential interrelationships among all the members of nature's community. Webbing vividly portrays how air, rocks, plants, and animals function together in a balanced web of life.

The children form a circle. The leader stands inside the circle near the edge, with a ball of string: "*Who can name a plant that grows in this area? . . . Brodiaea . . . Good. Here, Miss Brodiaea, you hold the end of the string. Is there an animal living around here that might eat the brodiaea? . . . Rabbits! . . . Ah, a sumptuous meal. Mr. Rabbit, you take hold of the string here; you are connected to Miss Brodiaea by your dependence on her flowers for your lunch. Now, who needs Mr. Rabbit for his lunch?*"

Continue connecting ~~the children~~ with string as their relationships to the rest of the group emerge. Bring in new elements and considerations, such as other animals, soil, water and so on, until the entire circle of children is strung together in a symbol of the web of life. You have created your own ecosystem.

To demonstrate how each individual is important to the whole community, take away by some plausible means one member of the web. For example, a fire or a logger kills a tree. When the tree falls, it tugs on the strings it holds; anyone who feels a tug in his string is in some way affected by the death of the tree. Now everyone who felt a tug from the tree gives a tug. The process continues until every individual is shown to be affected by the destruction of the tree.



ACTIVITY 1 The Aquatic Safari

Your group is in for a big adventure and lots of surprises when you stalk and collect aquatic creatures. An aquatic safari is different from a safari in Africa, however—you don't need to travel far to get there, the animals you'll be looking at are no bigger than your smallest finger, and you'll release everything that you catch alive.

You can collect and observe dozens, even hundreds, of insects in a single pan of stream water. Shallow streams with clear, cold running water are good habitats to sample. If your group members wade in a stream, they can pick up rocks and find many immature insects (nymphs and larvae) clinging to them. The only tools they will need for sampling are their hands, their eyes, and a shallow white-bottomed pan.

If your group is collecting samples from a pond or a stream with a sandy or silty bottom, they'll need nets to catch insects. In a pond, they will find the most insects in and around the aquatic plants along the water's edge.

> Caution: Make sure the youths work in pairs, and remind them that areas around streams and ponds can be slippery. When they are walking in a stream, encourage them to step cautiously and use a pole or net handle for support if necessary. Appropriate footwear (old sneakers, rubber boots) is essential, for there may be broken glass and sharp rocks on the bottom.

Take your group sampling in a stream and record what insects you see. Then go to a pond and record what you find there. Encourage the youth to think about their discoveries by asking the following questions: How do the insects in ponds behave compared with those in streams? Where are the insects larger? Better camouflaged? Faster moving? More aggressive? In greater numbers? More varied in size and shape?

Don't worry if you and the members of your group cannot identify every creature you collect by its proper name. Instead, look for characteristics that distinguish one organism from another. You'll be surprised how much you and your group will discover together about aquatic ecology.

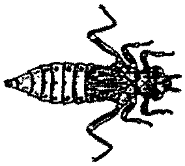
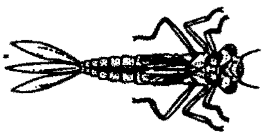
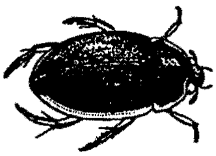
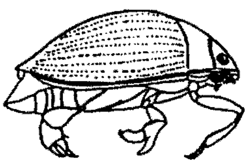
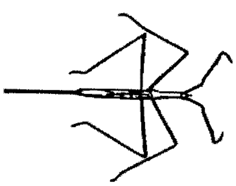
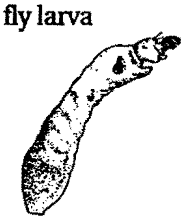
Before You Begin

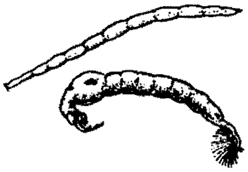
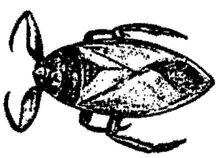
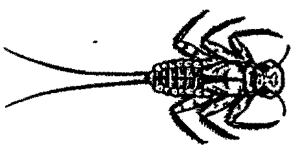
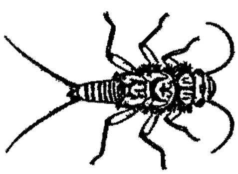
Take a few moments to discuss with your group the importance of insects and other invertebrates to aquatic food webs. Invertebrates provide food for a lot of other life in ponds and streams, particularly fish. Fish are food for many types of water birds, such as herons, eagles, and osprey, as well as for humans.

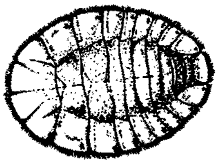
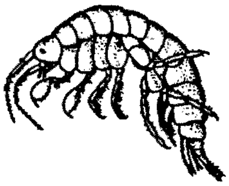
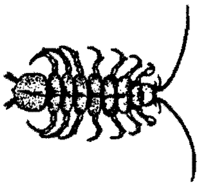
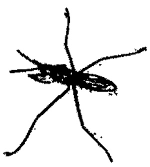
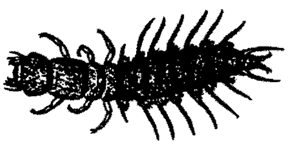
The respect that you and your group give to the creatures in the habitats you sample is an expression of how you care for the whole environment, because all creatures, including people, are interconnected. Although some insects may die in the process of collecting, emphasize to your group the importance of returning as many as possible alive to the stream or pond.

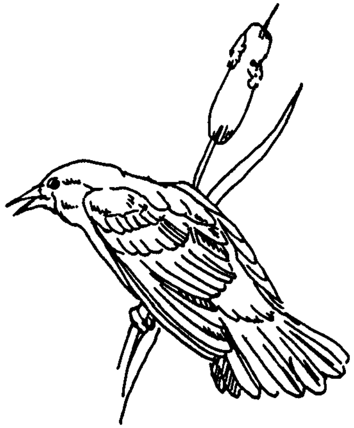
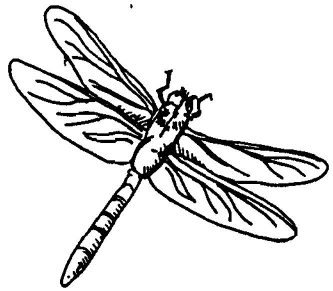
Note: If you think the stream from which you and your group are going to collect samples may be considered a sensitive trout stream by the agency that oversees fish and wildlife management in your state, check with your conservation officer before bringing your group to the site. The conservation officer may have suggestions about alternative sampling sites to choose. You may need to apply for a collection permit to sample there or to preserve organisms in alcohol for a permanent collection. In New York State, such a license costs $10 per year. Write to Special Licenses Unit, New York State Department of Environmental Conservation, Division of Fish and Wildlife, 50 Wolf Road, Albany, New York 12233-4752.

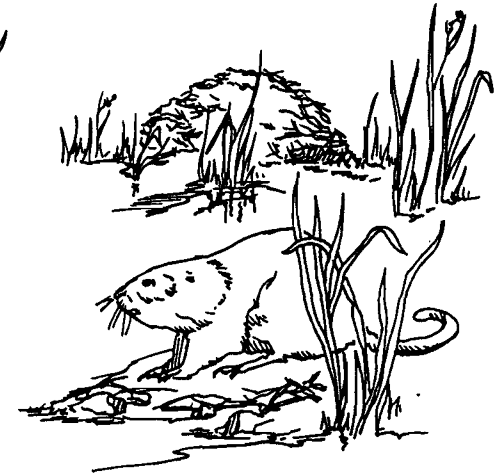
Checklist of Common Aquatic Invertebrates

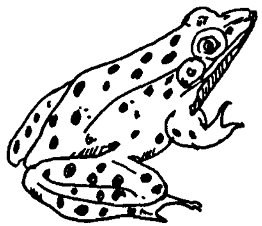
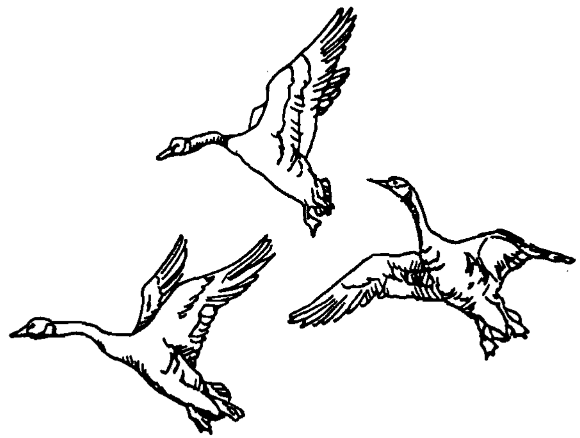
Aquatic Organism	Number Found in Pond	Number Found in Stream
Dragonfly nymph 		
Damselfly nymph 		
Water scavenger beetle adult 		
Whirligig beetle larva 		
Whirligig beetle adult 		
Water scorpion (adult) 		
Black fly larva 		

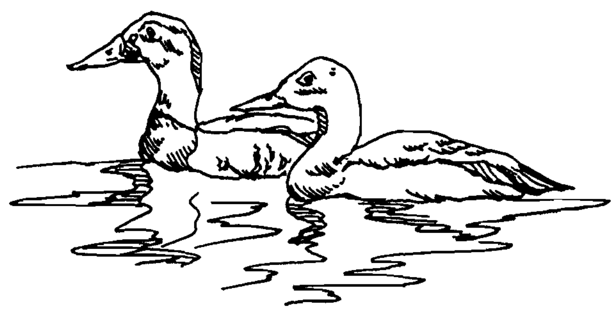
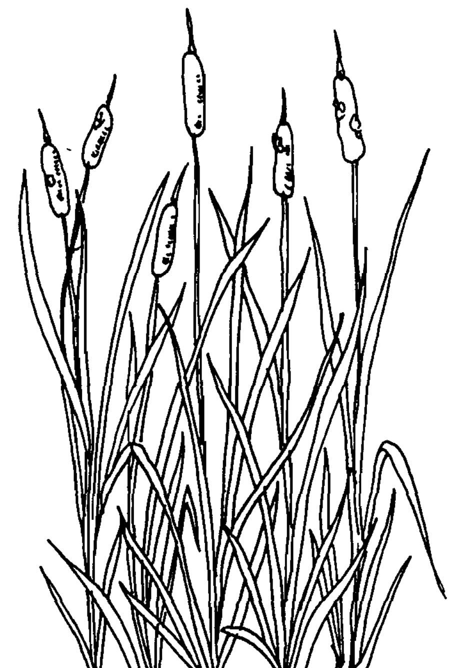
Aquatic Organism	Number Found in Pond	Number Found in Stream
Midge larvae 		
Water boatman (adult) 		
Backswimmer (adult) 		
Giant water bug (adult) 		
Mayfly nymph 		
Stonefly nymph 		
Caddisfly larva 		

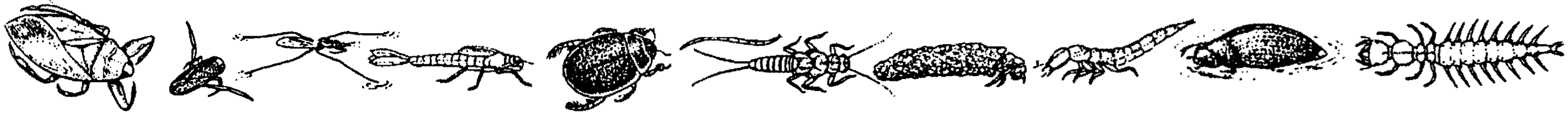
Aquatic Organism	Number Found in Pond	Number Found in Stream
Crane fly larva 		
Water penny (beetle larva) 		
Scud 		
Aquatic sowbug 		
Mosquito larva 		
Water strider (adult) 		
Dobsonfly larva (hellgrammite) 		





ACTIVITY 7 Weaving the Web

All creatures that live in ponds and streams rely on other plants and animals for their food. Food is a link between all animals, large and small. Small animals eat plants, and then those small animals are eaten by larger animals. The larger animals are eaten by still larger animals, and so on. These links through eating make up what is called a food chain.

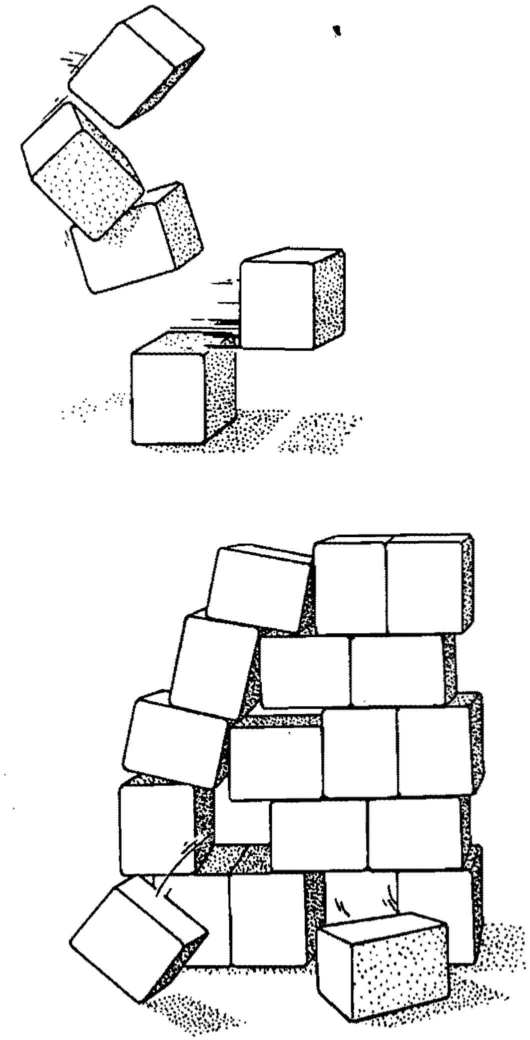
In real life, however, the connections are not so simple. One animal may eat a variety of foods, including plants and smaller animals. Other animals may eat plants, animals, and decaying matter. The chain becomes complicated and is known commonly as a food web.

A basic feature of the food web is a system of checks and balances, which keeps populations of one type of organism from dominating others. For example, algae overgrowth is prevented by a variety of algae-eating invertebrates. The populations of algae eaters are kept in check by their predators, both invertebrates (such as stoneflies and hellgrammites) and vertebrates (such as small fish). Large fish eat small fish, keeping the number of small fish in check.

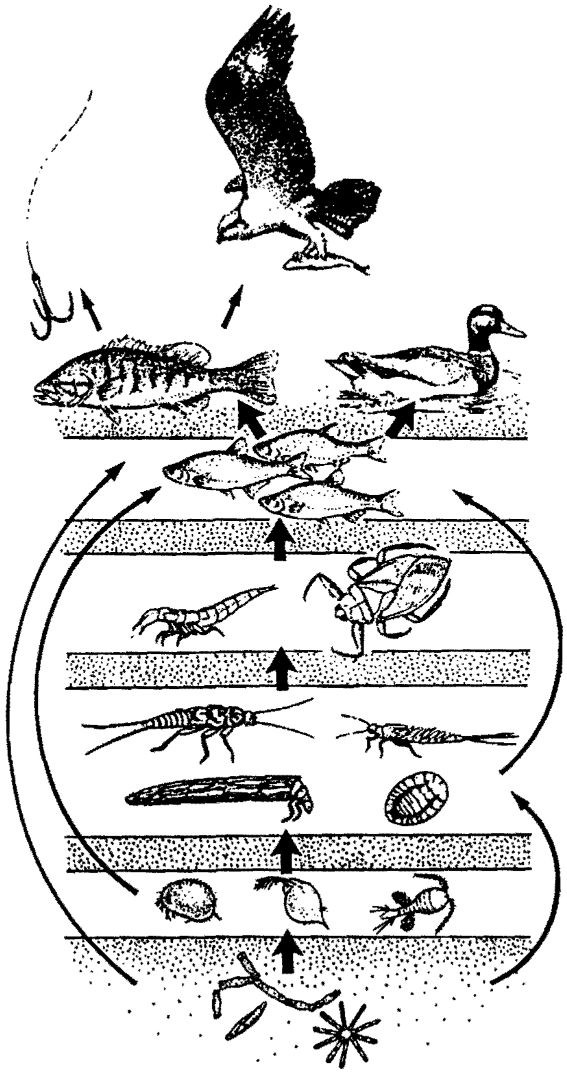
If there are many connections at each level of the food web, the web is strong and less likely to be damaged by disruptions in the environment. For an analogy, consider a structure made of children's building blocks. If the structure is made of many blocks at each level, it is less likely to collapse when one block is removed. If the structure is made of just a few vertical blocks, the building will collapse when one block is pulled out.

In this activity, you will give each member of your group a work sheet with pictures of many animals that are common to aquatic habitats such as the ponds and steams they have sampled. They will use their experiences (and knowledge) to construct a food web that is as realistic and also as strong as possible. Remember, the strength of a food web lies in the number of relationships that exist between organisms.

To help your group make some of the connections, several of the animals illustrated on the activity work sheet have the food they eat in their mouths.



Removing one block causes the structure on the top to topple. A structure made of many blocks (bottom) is stronger and not as likely to collapse when one block is removed.



In a food web, organisms are linked together by the food they eat.

What You'll Need

- a large blank sheet of paper for each group member
- copies of the activity work sheet for each group member (in folder)
- scissors
- masking tape or cellophane tape
- pens or colored markers

What to Do

1. Have the group members cut out the organisms illustrated on their activity work sheets.

2. Ask them each to arrange the pictures in a realistic order on a large sheet of paper. For example, plants at the bottom, plant eaters (herbivores) on the next level, predators on the next level, and larger predators at the top.

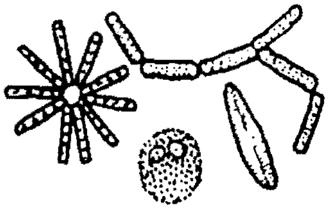
3. After they decide where everything should be placed, have them tape each picture onto their sheet of paper.

4. Ask them to draw arrows connecting each organism to the food it eats. For example, arrows would go from the algae to the mayfly and from the large fish to the fish hook. Some arrows may skip between levels of the food web; for example, mayflies can be eaten by stoneflies (the next level) and also by trout (two levels up).

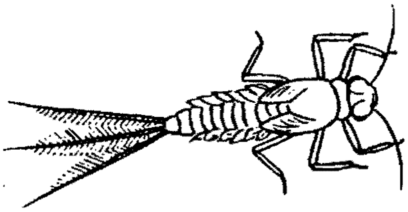
5. Have each member share their food web with the whole group. How does one food web differ from another? Why?

Activity 7 Work Sheet

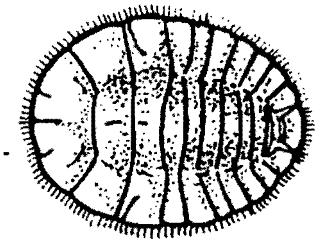
Bacteria and fungi



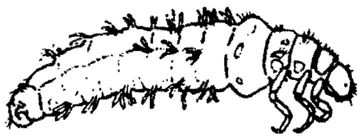
Algae and plankton



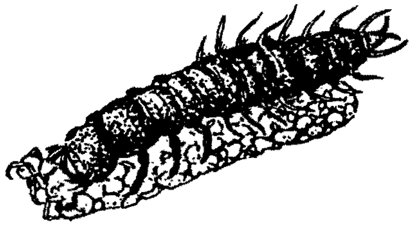
Mayfly nymph



Water penny larva

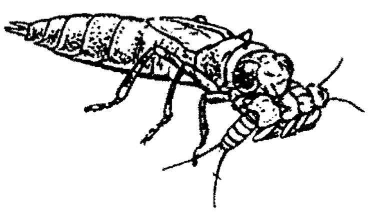


Caddisfly larva

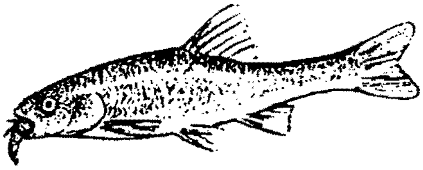


Hellgrammite (dobsonfly larva)

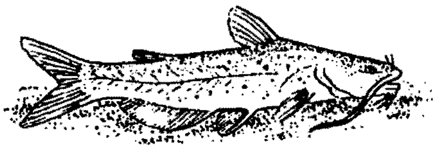
Stonefly nymph



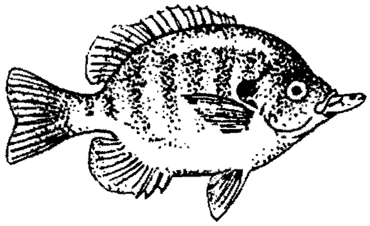
Dragonfly nymph



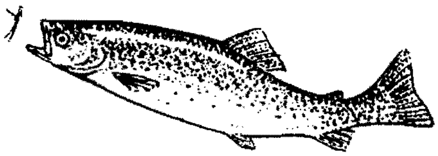
Minnow



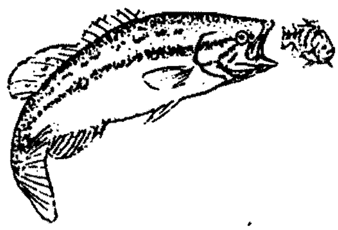
Catfish



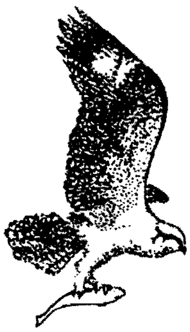
Bluegill



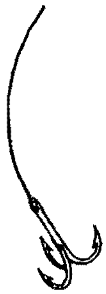
Trout



Largemouth bass



Osprey



Stream Study

Objectives:

- Identify and compare measurements
- Take measurements and conduct counts
- Graph information gathered
- Identify how aquatic plants and animals have adapted to their environments
- Discuss and illustrate the process known as the water cycle
- Identify and describe the effects of human activity on the environment

What to Teach	Teaching Suggestions
Introduce the concept of pollution to students.	- Background information: "Pond, Streams, Swamps, and other Watery Places." - Discuss what pollution consists of. See "Pollution – No Easy Answers" - Take students on a pollution scavenger hunt around the school grounds following the guidelines under "Pollution Patrol." - Have students discuss what was found. - Background information: "Troubled Waters"
Q: How does pollution affect our waterways and the water we drink?	- Follow the activity "Away with Waste"
Discuss ways people pollute our waterways and the effects of water pollution on all organisms.	- Q: Is it important that we care for our waterways?
Introduce the concept of a watershed	- In the town of Away, all pollution ended up in the Bay. Where does our water go that we flush down the sink? Where does the water go that comes off of our lawns? - Do the activity titled "Go with the Flow"

What to Teach	Teaching Suggestions
Have students trace where their water goes on a local and/or state map.	- All of our water, that doesn't soak into the ground, ultimately ends up in the Gulf of Mexico. - Water from Annehurst will flow into: 1. Spring Creek 2. Alum Creek 3. Big Walnut Creek 4. Scioto River 5. Ohio River 6. Mississippi River 7. Gulf of Mexico
Discuss the water cycle.	- Q: Where does the water come from that flows into our watershed? - A: Rain, snow, hail, etc. = precipitation - Q: Where do the clouds come from that produce this precipitation? - A: They are produced through the cooling of water that had evaporated from trees, plants, lakes, and streams.
Lead students through the steps of the water cycle.	- Follow the outline "The Water Cycle" and fill in the activity sheet.
Introduce Spring Creek at Sharon Woods. Discuss with students what lives in and around Spring Creek. Show pictures if available.	- We've been discussing were the water comes from that feeds Spring Creek, here behind the school in Sharon Woods. We've also been discussing where the water goes that is in Spring Creek. Now, let's discuss what we can find in and around the creek. - Most students will be able to name the vertebrate and crustaceans (ie. Raccoons, deer, muskrat, turtles, sakes, snails, salamanders, crayfish, and various songbirds). - Ohio creeks should also contain creek chubs, darters, bluntnose minnows, etc.

What to Teach	Teaching Suggestions
	- Many insects and/or their larvae can also be found in Ohio creeks. See "Aquatic Insects"
Discuss the various insects and insect larvae that can be abundant in Spring Creek.	- See "Macroinvertebrate Identification Guide" and the other various information sheets in this section and under the pond study section.
What can the number of insects found tell us about a stream?	- By knowing the pollution tolerance of certain groups of macro-invertebrates, we can determine how "clean" a stream is. - See "Macroinvertebrate Taxa Groups", "Creek Critter Walk", and "Biotic Index."
Q: How healthy or clean do you think Spring Creek is?	- Take into consideration where the stream comes from.
Visit to Sharon Woods Metro Park.	**- We will determine the biotic health of Spring Creek by seining and netting insect larvae, fish species, and other aquatic organisms. The naturalist will discuss with students how many of the aquatic organisms have adapted to their life in the creek.**
Maintain a record of organisms found.	- Use the checklist of "Common Aquatic Invertebrates" to record the number and types found. Keep the records and compare with those numbers found in Schrock Lake.
Discuss what was found.	- Were any signs of pollution found? - Was it surprising to learn what the health of the creek was? - What was the most interesting organism found?

What to Teach	Teaching Suggestions
Graph type and number of organisms found.	- Have students use various types of graphs to graph the counts of organisms found in Spring Creek.
What can the graphs tell students about Spring Creek?	- What type of organisms were most abundant? Which were least abundant? - How does Spring Creek compare to Schrock Lake?
Now that the students have studied pollution and seen first-hand the effects pollution can have on a waterway, test their pollution I.Q.	-Have students do the activity titled "Pollution Pursuits" to finish out this section.

POLLUTION—NO EASY ANSWERS

A haze of thick smog. An oil spill. An overflowing landfill. It's no to find examples of pollution in our society. But it is hard to define e what pollution is. For example, is a can tossed on the ground polluti How about an unsightly billboard? The noise from a nearby airport?

According to experts, all of these examples can be types of pollution. Broadly defined, pollution is any human-caused change in the environment that creates an undesirable effect on living and nonliving things. Most types of pollution cause some type of physical harm. But some don't. Noise, for example, often creates more psychological damage than physical damage, but it's still considered a type of pollution. In short, pollution is bad stuff—for the environment and for people and other living things.

From Manure to Monoxide: For thousands of years, pollution wasn't much of a problem. As long as people lived in scattered settlements and the world's human population was relatively small, the earth's natural systems could accommodate the effects of human waste. But once people began to live in cities and to invent machines and synthetic chemicals, pollution started taking its toll. Pollution has been linked to the fall of Rome (lead in the pipes); the cholera epidemic in 19th-century London (garbage in the streets); and many other significant events throughout history.

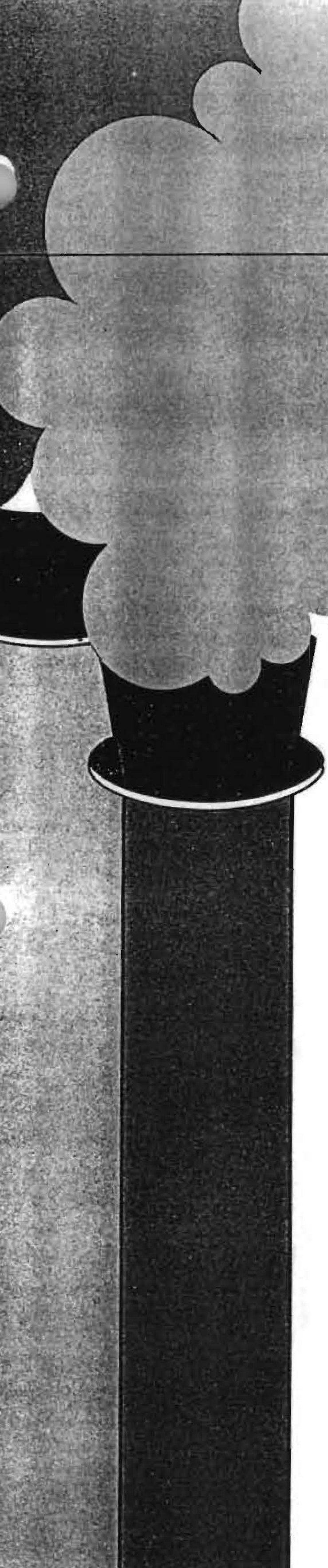
Though pollution has been around for thousands of years, the sources of our pollution problems have changed, and the amount of pollution has increased dramatically. A century ago, people were dealing with pollution from animal waste, coal ash, and open dumps. Today, pesticides, fertilizers, radiation, carbon monoxide, acid rain, and a host of other "new" and toxic pollutants are the troublemakers. This increase in the amount, number, and toxicity of pollutants, combined with an ever-increasing human population, has made pollution worse than ever before—threatening the very integrity of earth's life-support systems.

Hard to Pin Down: In this issue, we focus on air, water, and land pollution. However, in many cases the categories overlap. For example, pesticides can contaminate air, water, and land, depending on how they are manufactured, used, and disposed of. Many pollutants also travel great distances and can change form, making it hard to pin down exactly where they came from.

The effects of pollution can also be hazy. For one thing, pollutants can affect different people in different ways. People with respiratory problems and allergies, for example, are often more sensitive to air pollution than people without these problems. And it's often hard to tie adverse health effects to specific types of pollution. In general, pollution can cause serious and immediate problems, such as injury or death, as well as chronic, long-term problems that can take years to surface.

Pollution does more than affect human health. It also limits our activities, harms wildlife and habitat, defaces buildings, and has the potential to disrupt the planet's natural systems, including global climate patterns.

No Single Cause: Almost every human activity—from how we get around to how we grow our crops—creates some type of pollution. And a combination of factors, from economics to politics to ethics, further complicates pollution problems. (For more about the causes of air, water, and land pollution, see the background information in each chapter.)



Technological advances designed to make our lives easier, such as the internal combustion engine and plastics, have created some of our most pressing pollution problems. But technology alone isn't the culprit. Our reliance on convenience items is also part of the problem. The lack of economic incentives to produce pollution-free products, as well as the fear that pollution controls will reduce jobs, lower our standard of living, and keep us from competing in foreign markets, are part of the problem too.

Not understanding the consequences of pollution is also part of the problem. For years, people thought that they could safely get rid of garbage, sewage, exhaust, and other waste products by throwing them away, flushing them down the drain, or releasing them into the air. But we're now realizing that the waste we dispose of can come back to haunt us in a variety of forms.

Poverty and Pollution: Pollution is intrinsically linked to social problems, such as poverty and overpopulation. In many cases, people on limited incomes cannot just move away from a chemical dump site or a smog-filled city. They can't afford to drink bottled water or pay for organically grown vegetables. The struggle to simply survive forces them to take risks that others can afford to avoid. And when poverty is combined with the pressures of overpopulation, which it often is, both pollution and poverty are exacerbated.

Weighing the Risks: We know that some pollution will always exist. But how much pollution is acceptable? What are the short- and long-term risks of a polluted environment to individuals, communities, and society as a whole? To deal with questions like these, policymakers are starting to rely on a relatively new and imprecise process called *risk assessment*. Risk assessment helps people understand and quantify the risks posed by using certain technologies and not using others, including the probability and severity of the risks. But determining and evaluating risks is often extremely difficult. In many cases, data on the risks involved with new technologies don't exist, and scientists must rely on computer models that have no proven reliability. And it's hard to quantify intangibles such as the loss of an endangered species or an ecologically pristine site. Even if risks can be calculated, risk assessment is controversial because some technologies benefit certain people while imposing risks on others.

A Question of Values: In the past, we've spent most of our efforts *cleaning up* pollution rather than *preventing* it. But experts are now looking more to reducing the pollution we produce in the first place. In the long run, preventing pollution saves money, protects resources, prevents health problems, and improves the overall quality of life. But making the decision to prevent pollution involves more than politics, economics, and health. It also involves values. Taking into account both short- and long-term risks, people must rely on their own value systems to decide how important it is to prevent pollution now—for themselves, for their neighbors, for society as a whole, and for future generations.

Pollution Patrol

Go on a scavenger hunt to search for signs of pollution.

Objectives:
***Define* pollution.**
Describe several examples of pollution.

Ages:
Primary, Intermediate, and Advanced

Materials:
- *chalkboard or easel paper*
- *copies of clues on page 5*
- *magazines (optional)*
- *scissors (optional)*
- *glue (optional)*
- *construction paper (optional)*

Subjects:
Science and Social Studies

Your kids can go on a "pollution patrol" scavenger hunt to look for different types of pollution and signs of potential pollution in their community.

Begin the activity by asking the kids what kinds of things come to mind when they think of pollution. List their ideas on a chalkboard or sheet of easel paper. Then use the background information on pages 2-3 to explain what pollution is. Ask the kids if they want to add any other examples to their list or delete any that they suggested before.

Next tell the group that they will be going outside to look for some of the types of pollution that you talked about. Tell the kids to be on the lookout for signs of pollution in the air, in water, and on land. They should also keep noise pollution in mind.

For Younger Kids

Before taking the group outside, show the kids examples of pollution "evidence" they might find on their scavenger hunt. You might bring in things such as an empty beverage can, some litter from a fast-food restaurant, an empty container of household cleaner, and other examples of trash. Or you could show pictures of cars, smokestacks, outdoor grills, and so on to give the kids ideas about what to look for.

Once you're outside, tell the kids that they should rely on their senses to help them locate and identify pollution. For example, they might smell exhaust from nearby cars, see oil spots on the road, or hear noise from a plane taking off or flying overhead. You may want to have the children work in teams, with each team focusing on just one form of pollution. For example, different teams could search for pollution they can see, hear, or smell. Or they could search for pollution that's on land, in water, or in the air. Each time someone comes across a different kind of pollution, stop to discuss where it might have come from and what effect it might have on wildlife and the environment. (See "What Makes It Pollution?" on the next page for some ideas.)

For Older Kids

Before going outside, use the pollution examples in **bold** type under "What Makes It Pollution?" on the next page to make up a scavenger hunt clue sheet. Then pass out a copy of the clue sheet to each person. Explain to the kids that they can work in pairs to try to look for the signs of pollution listed on their clue sheets. They can also add signs they find that aren't included in their scavenger hunt list.

Now take the kids outside. Tell them to think about whether each type of pollution they find affects air, land, water, or some combination of the three. Also tell them to think about whether each type of pollution affects people or wildlife in some way.

When the kids have finished their walk, go over the list. Have the kids take turns describing where they saw various signs, and then discuss the likely sources of pollution and the possible consequences. Use the information under "What Makes It Pollution?" to help with the discussion. (You might also want to read through the background information in chapters two, three, and four for more detailed information about the effects of pollution.)

If there aren't many signs of pollution in your immediate area, have the kids look for them around their neighborhood or on their way to and from your meeting area. Or have them do their scavenger hunt inside by searching for the clues in magazines. They can work in small teams to cut out pictures and make pollution collages. Tell them that they can include examples of things that could contribute to pollution even though the picture may not show the pollution itself. For example, a picture of laundry detergent or a washing machine could symbolize the fact that many kinds of detergent contain phosphates—chemicals that can pollute surface water and groundwater. Or the kids might include a cigarette

ACTION TIP!

OPERATION CLEANUP

Have your kids plan a community cleanup campaign, using what they found out about pollution in their community. For example, they could follow up their scavenger hunt with a litter pickup project. And for problems that are more difficult to solve, such as local problems with air and water pollution, the kids could write letters, work on a pollution fact-finding mission, or help educate others about pollution in the community. To help them get started, try "Clean Up Your Act!" on page 72.

ad and describe how cigarettes can contribute to the problem of indoor air pollution. (For more about indoor air pollution, see page 35.) When they have finished, have the teams present their collages to the rest of the group.

WHAT MAKES IT POLLUTION?

(*Note:* This list does not include all the problems related to each entry. For example, there are a number of pollution problems related to plastic foam, but we've included only those related *directly* to plastic foam *litter*.)

oil stains on pavement: rain can wash oil into water supplies
aluminum beverage can: unsightly; doesn't biodegrade; sharp edges may injure wildlife or people; small creatures may get trapped inside
paper litter: unsightly; inks and bleaching chemicals can contaminate soil and water
plastic six-pack ring: unsightly; doesn't biodegrade; may strangle wildlife
litter in a pond, lake, stream, or other body of water: unsightly; may injure aquatic animals that get stuck in litter or try to eat it
lawn-care truck: lawn-care products contain chemicals that may harm wildlife, pets, and people; rain can wash chemicals into water supplies

USDA—Soil Conservation Service

construction site: noise may be annoying and may damage hearing of construction workers; construction dust may pollute air; rain can wash uncovered soil into surface water; creates solid and hazardous waste
car, truck, or bus exhaust: pollutes air; harms human health; may contribute to global climate change
storm drain: rain washes litter, soil, chemicals, and other pollutants into the drain, which carries pollutants into surface water
animal waste: rain can wash waste into water supplies; can harm human health
household chemical container: unsightly; can leak harmful chemicals into soil, water, or air
jet or airplane noise: annoying; may damage hearing of people who live near or work at airports
smog: harms human health
overflowing trash container: unsightly; litter may trap or choke wildlife
traffic noise: annoying
glass litter: unsightly; broken glass may injure people or wildlife; small creatures may get trapped inside jars or bottles
smokestack: releases pollutants into air
aerosol spray can: may contain air-polluting propellants or chemicals that can harm people or wildlife
plastic foam litter: unsightly; doesn't biodegrade; may injure animals that mistake bits of plastic for food
discarded tires: unsightly; may catch on fire and release harmful pollutants into soil, water, or air
roadside dump: unsightly; may contain hazardous materials that can leak into soil, water, or air; different types of materials may harm wildlife in different ways (poisoning, choking, trapping, and so on)
smoke from a chimney: pollutes air; may contribute to global climate change
gasoline pump: nozzle releases toxic fumes; underground storage tank may leak gasoline into water supplies
person spraying garden pesticide: chemicals may harm people or pets; may kill species other than the targeted pests; rain can wash chemicals into water supplies
candy or gum wrapper: unsightly; foil and plastic doesn't biodegrade
bare soil on a slope: rain can wash soil into surface water

TROUBLED WATERS

When you bite into a juicy, spot-free apple, you probably don't think about water pollution. But there's a direct link between "perfect" apples and tainted water: Most of the apples we eat have been sprayed with pesticides to control insect damage. And these pesticides often wash into water supplies, contaminating drinking water and poisoning wildlife.

The link between water pollutants and their source isn't always obvious. But water quality experts agree that understanding what causes water pollution is the first step toward solving the pollution problems that plague our lakes, streams, rivers, oceans, and underground water supplies.

WATER POLLUTION AT THE SURFACE

Surface water is easy to see: It's the water that flows in our rivers and streams and that fills our lakes, bays, and oceans. *Groundwater,* however, is hidden from view: It fills the spaces between soil particles and rocks underground. (See page 58 for more about groundwater.)

In general, the pollutants that reach surface water come from one of two sources. *Point* pollution comes from readily identifiable sources, such as a pipe draining from an industrial plant or sewage treatment facility. This type of pollution is relatively easy to track down and control. *Nonpoint* pollution, however, cannot be traced to any one source and is much more difficult to control. Nonpoint water pollution includes *runoff,* which is all the material that washes off city streets, suburban lawns, and agricultural land, and all the air pollutants that fall into waterways.

Here's a rundown of the materials that get into surface water—from both point and nonpoint sources—and the problems they can cause.

Tiny Troublemakers: When disease-causing organisms such as bacteria and viruses get into surface water, they can spread dysentery, hepatitis, and other diseases. One of the major sources of these organisms is untreated human waste. In most areas of the U.S., water carrying human waste passes through sewage treatment plants before being released into surface water. Sewage treatment plants treat wastewater to kill disease-causing bacteria and viruses. But during heavy storms, the wastewater coming into the plants may back up and overflow directly into surface water without being treated. Untreated waste can also wash directly into surface water if a treatment plant isn't working properly. (In some parts of the U.S., wastewater is treated by septic systems instead of sewage treatment plants. And many of these septic systems can cause groundwater pollution. See page 58.)

Oxygen Hogs: Untreated human waste can do more than transmit diseases; it can also rob water of oxygen. And other biodegradable waste that gets into surface water, such as animal and food waste, can have the same effect. That's because this waste is broken down in the water by bacteria and other organisms that use oxygen to do their "work." And these organisms may use so much of the oxygen in the water that fish and other aquatic organisms can't survive.

Malfunctioning or overloaded sewage treatment plants are one source of biodegradable waste. Another is runoff. Tremendous amounts of animal waste wash into surface water from feedlots and other agricultural land each year. And runoff from yards and streets often carries yard and pet waste.

Green Growth: When nitrate-containing fertilizers and phosphate-containing detergents get into surface water, they can deplete oxygen supplies, just as biodegrad-

able waste can. The nitrates and phosphates in these products act as fertilizer for algae and can cause them to grow at a tremendous rate, creating huge algal "blooms." As the algae grow, die, and decompose, they use a lot of the oxygen in the water. Nitrates and phosphates can also cause other problems. For example, nitrates can end up in drinking water and make the water unfit to drink.

Chemical Cornucopia: There are more than 65,000 commercially available chemicals in the U.S. These chemicals are ingredients in many products we use every day and are also used in many industrial processes. Unfortunately many of them also end up polluting our water.

Some of these chemicals are dumped directly into water. For example, each year industries legally dump more than 500 million pounds of toxic chemicals directly into surface water. But a lot of chemicals get into surface water inadvertently. For instance, runoff carries tons of pesticides, heavy metals, and other chemicals into surface water each year.

Chemicals that get into surface water can poison fish and other animals outright. They can also accumulate to toxic levels in the tissues of animals. And they can accumulate in bottom sediments, forming reservoirs of chemicals that can continue to affect aquatic life for years.

Poisons from the Sky: In parts of the Northeast and in other areas, lakes once teeming with fish, aquatic insects, and many other species are now almost devoid of life. The culprit? Acid rain.

Acid rain can kill aquatic life in several ways. For example, so much acid rain may fall in an area that the pH of surface water drops. Since many aquatic species are adapted to living only within a certain pH range, the change in pH may be enough to kill them or prevent them from reproducing. (For more about pH and acid rain, see "Acid Tests" on page 42.)

Acids, however, are not the only compounds reaching surface water from the air. PCBs, DDT, and other airborne toxics, some of them carried in the atmosphere for thousands of miles, also end up in surface water. These compounds may kill animals directly, build up in their tissues, or cause disease. And when people and other animals eat aquatic creatures contaminated with these chemicals, they may develop serious illnesses.

A Dirty Problem: When rain runs off land that's been disturbed by bulldozers, logging trucks, and other equipment, it picks up dirt and silt and carries them into surface water. Dredging operations also dump a lot of sediment into surface water. Once in the water, sediment can keep sunlight from reaching aquatic plants, can clog fish gills, and can smother bottom-dwelling organisms.

Oily Messes: Any time a tanker runs aground and spills millions of gallons of oil into the sea, the event makes world headlines. But the amount of oil spilled in accidents like this represents only a fraction of the total amount of oil that contaminates our water resources each year. For example, tankers routinely dump oil into the oceans when they clean out their tanks, refineries pump oil-laced wastewater into surface water, and oil from city streets washes into surface water.

Oil's effects on wildlife can be devastating. Some animals, including birds, mammals, and fish, may be killed by ingesting the oil. Many others may die from eating contaminated prey or by getting their feathers or fur coated with oil, which causes them to lose their ability to stay warm.

(continued next page)

GROUNDWATER: THE HIDDEN RESOURCE

Approximately half of the people living in the U.S. rely on groundwater for their drinking water. Groundwater is also one of the most important sources of irrigation water. Unfortunately some of the groundwater in every state has become tainted with pollutants. And some scientists fear that the percentage of contaminated groundwater may increase as toxic chemicals dumped on the ground during the past several decades slowly make their way into groundwater supplies.

So What Is Groundwater? Many people picture groundwater as underground rivers or lakes. But, as we mentioned earlier, it's actually water that fills the spaces between rocks and soil particles underground—in much the same way as water fills a sponge. Most groundwater is precipitation that has soaked into the ground. And groundwater sometimes feeds lakes, springs, and other surface water.

A Seeping Problem: Pollutants that contaminate groundwater seep into it through the ground. And the pollutants themselves are many of the same compounds that contaminate surface water. For example, pesticides and fertilizers often seep into groundwater supplies. Road salt, toxic substances from mining sites, and used motor oil may all end up in groundwater too. Untreated waste may leak into groundwater from faulty septic tanks. And toxic chemicals may leach out of landfills or leak from underground storage wells and seep into groundwater. Unlike tainted surface water, contaminated groundwater can be almost impossible to clean up.

The Health Impact: Contaminated groundwater can have serious health effects. For instance, people whose drinking water has become contaminated by septic tank waste may contract hepatitis, dysentery, or other diseases. People may also be poisoned by toxics that have seeped into their well water. And if they drink water contaminated with certain chemicals over a long enough period of time, they may develop liver and kidney problems, cancer, or other serious illnesses. Contaminated groundwater can also harm wildlife if it gets into surface water.

PROTECTION AND PREVENTION

Finding answers to our water pollution problems won't be easy. For one thing, in addition to the pollutants we've already mentioned, there are others getting into our water that we must deal with too, such as radioactive waste, heated industrial wastewater, and trash. There are also many stumbling blocks in the way. For example, cleanup of toxic waste dump sites that could be or are polluting groundwater is progressing slowly because of legal battles over responsibility and high cleanup costs. And many of the laws designed to protect our water resources are not being enforced. But because water is such a vital part of our lives, there's too much at stake *not* to deal with the problems.

New Technologies: One thing people are working on is the development of new methods of treating wastewater. For example, people-made wetlands and other systems that are often cheaper and cleaner than traditional treatment plants are being used in some communities to treat sewage. People are also trying to find new ways to remove toxics from water and from bottom sediments.

An Ounce of Prevention: Cleaning up polluted water can be extremely expensive. So keeping pollutants out of our water in the first place is the best way to ensure that we have clean water. Many individuals and industries around the country are taking steps to do just that. For example, some industries are reducing their production of toxic chemicals and developing ways to make their products without using toxic raw materials. And many people have switched to phosphate-free detergents and other less-polluting products. In addition, governments are passing tough water pollution control measures designed to prevent water pollution. (See page 83 for information about legislation designed to protect water.)

Away with Waste!

Listen to a rhyming story to find out about sources of water pollution.

Objectives:
Describe some of the ways people pollute waterways. Describe some of the effects of water pollution.

Ages:
Primary and Intermediate

Materials:
- ***story on page 60***
- ***drawing paper***
- ***crayons or markers***
- ***construction paper (optional)***
- ***stapler (optional)***
- ***glue (optional)***
- ***copies of page 60 (optional)***

Subjects:
Science, Language Arts, and Art

By listening to a rhyming story about water pollution in one community, your kids can discover how pollution can affect waterways. They'll also discover that the waste we wash "away" can have harmful effects later on.

Before reading the story, ask the kids to name some of the ways they use water. (for drinking, bathing, brushing teeth, cleaning clothes and dishes, and so on) Then ask them what happens to the water that drains out of their washing machines and dishwashers or washes down their sinks. (Don't worry whether the kids know the answer at this point. You'll be discussing what happens to household water with them after they hear the story.) Explain that many people never think about what happens to the water they use in their households each day. They also don't think about what happens to the water that runs off their streets and yards.

Now tell the kids you're going to read them a story about a town called "Away" and about how people in the town polluted the water in a nearby bay without realizing what was happening. Tell the kids to listen carefully to the story to find out just how the water in the bay became polluted. Also tell them to listen for the word "away." Each time they hear it they should make a "hitch-hiking" motion over their shoulder with their thumb to represent something going away.

After you read the story, discuss it with the kids. Ask them if waste from Away simply disappeared. (no) What happened to the waste? (it ended up in the bay) Then go over the verses in the first half of the story to be sure the kids understood what was happening in each one. Use the information under "Where Did It Go?" below to help with the discussion.

Afterward pass out crayons or markers and drawing paper and have the kids draw pictures of the story. They might draw the people in the town, the bay when it was polluted, or the bay when it was cleaned up again. If you're working with older kids, you might want to have them create their own picture books of the story. Pass out copies of page 60 and have the kids draw a picture to go along with each verse of the story. Then have them glue their pictures on sheets of construction paper, copy the words of each verse onto the pages, and staple the pages together.

(continued next page)

Where Did It Go?

Down the Drain: When most people in the U.S. rinse something down their drain, flush their toilet, or do a load of wash, the wastewater goes to sewage treatment plants to be purified. These plants remove dirt, biodegradable material such as food waste, and many other pollutants from the water before the water is dumped into waterways. They also treat the water to kill harmful bacteria and viruses. But most plants can't remove all the chemical pollutants. For example, chemicals that are used in paint thinners and phosphates that are used in many detergents pass right through some sewage treatment plants.

Off the Streets: Oil, dirt, litter, and anything else that's on the streets washes into storm drains. In most areas of the country, these drains empty into a series of underground pipes that eventually dump directly into waterways.

Industrial Pollution: Factories that make chemicals, paper, medicines, steel, and many other products can create a lot of pollutants. At one time, industries could legally dump waste into waterways. But pollution-control laws now limit the materials that industries can dump into surface water. These controls have greatly reduced water pollution. However, not all the types of industrial waste are regulated. In addition, some experts feel that some of the regulations are not strict enough to protect aquatic systems.

Trashing the Water: When trash gets thrown overboard it can create an ugly mess—both in the water and on shore after it's washed up. Trash can also harm or even kill wildlife. For example, thousands of sea birds and marine mammals die each year after eating or becoming entangled in plastic debris floating in the ocean.

Away On The Bay

This is the tale of a town called **Away**—
A town that was built on the shore of a bay.
A town where the folks didn't think much about
What they dumped in their water day in and day out.

For one thing, a sink was an excellent place
To get rid of messes and not leave a trace.
Cleansers and cleaners and yesterday's lunch
Went **away** down the drain with a gurgly crunch.

At everyone's house there was laundry to do.
Day after day, how those laundry piles grew!
Load after load was washed, rinsed, and spun
And **away** went the water when each load was done.

On Main Street each day there were sidewalks to sweep.
The litter and dirt were swept into the street.
And then when it rained, everything washed **away**
Into drains in the roads that dumped into the bay.

A mill there made "stuff" for the townfolks to use,
But a pipe from the mill churned out oodles of ooze.
And the ooze, well it goozed from the pipe to the bay
Where it bubbled and glubbed as it drifted **away**.

When the weather was warm, it was always a treat
To sail on the bay and bring picnics to eat.
But when folks were finished, they'd toss all their trash
Overboard and **away** with a plop and a splash.

Then folks started seeing that things weren't quite right;
The bay had become an unbearable sight.
Beaches were covered with garbage and glop
That rolled in with the waves—and the waves didn't
stop.

The fish in the bay all seemed sluggish and sick,
The algae was everywhere—slimy and thick.
The birds near **Away** were all suffering too,
'Cause the fish they were eating were covered with goo.

So a meeting was called to discuss the sick bay
And townspeople came from all parts of **Away**.
And during the meeting one person proclaimed,
"I know who's at fault: We *all* should be blamed."

"For years we've washed chemicals, dirt, and debris
Down our sinks, off our streets, and out pipes—
so you see,
Although we all thought that our waste went **away**,
It all ended up going into the bay."

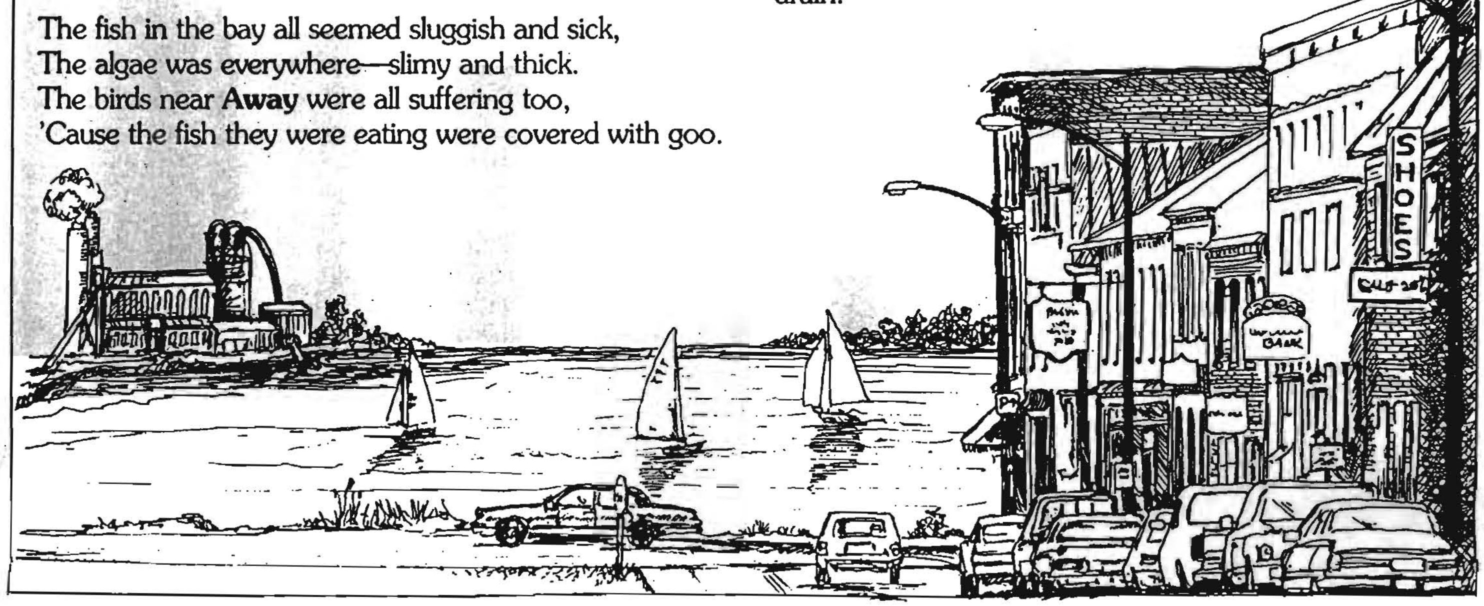
"Now the bay is a mess—full of trash, soap, and goop,
The water's turned green—like a bowl of pea soup.
And our wildlife is sick from the garbage and grime;
The bay needs our help, right now while there's time."

The folks were all silent—they knew it was true.
And they realized now what they all had to do.
It was time to get busy—the bay couldn't wait.
If they didn't act now, it might soon be too late.

So they signed an agreement that very same minute
To care for the bay and to stop putting in it
The stuff that had made the bay icky and ill,
Like soaps that pollute and the ooze from the mill.

They also agreed to stop dumping their trash
Overboard and **away** with a plop and a splash.
And all of their efforts have been a success:
Today the bay's clean and no longer a mess.

And that is the tale of the town called **Away**—
A town where the people, to this very day,
Remember a saying that's simple and plain:
Nothing just goes **away** when it's washed down the
drain.



Go with the Flow

Study a watershed, and then map your local watershed.

Objectives:
***Define** watershed.*
Explain how pollutants can affect water quality in a watershed.

Ages:
Advanced

Materials:
- ***copies of page 68***
- ***markers or colored pencils***
- ***state highway, regional, or topographic maps***
- ***tracing paper***
- ***masking tape***

Subject:
Science

No matter where you live, you live within a watershed. Conditions within that watershed greatly affect the quality of the rivers and streams flowing through it. After learning about watersheds, the kids in your group will have a better understanding of how water can become polluted. But before you do this activity, make sure the kids are familiar with some of the different kinds of water pollution. You might want to do "Guilty or Innocent?" on page 61 with the kids to introduce them to some forms of water pollution.

PART 1: UPSTREAM, DOWNSTREAM

Begin by asking the kids if they've ever seen splotches of oil in a parking lot or driveway. Then tell them that by doing this activity they'll find out what eventually happens to this oil.

Next introduce the group to the term *watershed.* Using the diagram in the margin on the next page, explain that a watershed is an area of land from which rainwater and snowmelt drain into a particular stream or river. Watersheds may be small areas of land that drain water into small streams or huge areas of land that drain water into large rivers. And within each large watershed there are many smaller watersheds. A watershed is usually named after the stream or river it drains into.

Point out that as rain and snowmelt flow across land and into waterways, they wash over everything in their path: golf courses, roads, fields, lawns, woodlands, and so on. And they pick up and carry material along the way: trash, dirt, pesticides, oil, and so on.

Next pass out copies of page 68 to the group. Tell the kids to use the map at the top of the page to answer the questions on the bottom of the sheet. (If the kids are having trouble determining the boundaries of the watershed, have them look at the streams on the map to see which way they flow. Those flowing into the Cedar River are in the Cedar River watershed. See diagram on the next page.) Afterward go over the page with the kids, using the answers on the next page.

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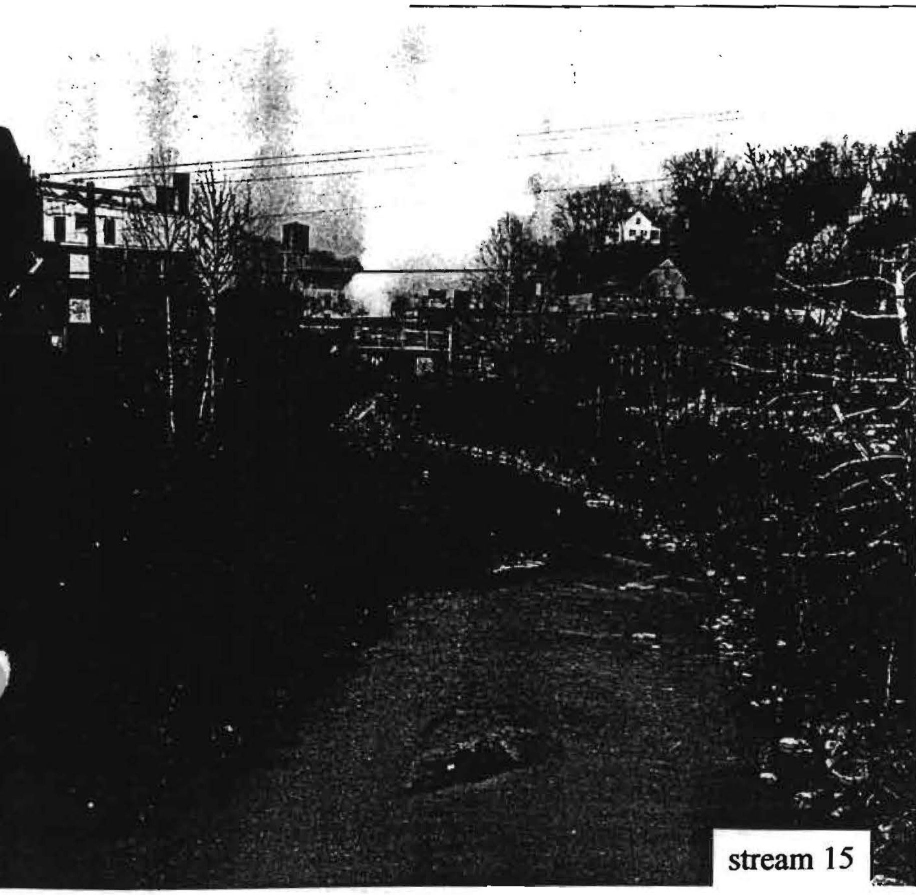
Part 2: Local Waters


USDA—Soil Conservation Service

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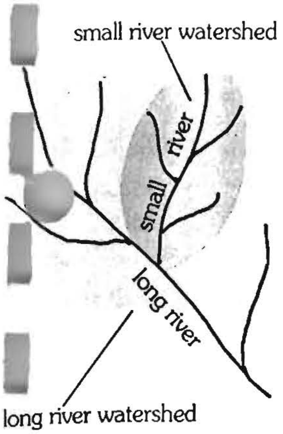
Now have the kids map the watershed they live in. Pass out state highway, regional, or topographic maps of your area that show a stream or river flowing through (or near) your community. (For topographic maps of your area contact the U.S. Geological Survey, Map Sales, Box 25286, Denver, CO 80225.) Also pass out sheets of tracing paper, masking tape, and colored pencils or markers and tell the kids to follow these directions:

1. Find your community and the nearest stream or river on the map. Then tape tracing paper over that section of the map. (*Note:* As we discussed in the answers to Part 1, slope is the factor that separates one watershed from another. Depending on the slope of the land in your area, the watershed of the *nearest* stream or river may or may not include your community. The only way to tell is to look at slope on a



ACTION TIP!
HELP A LOCAL WATERWAY

Your group can organize a cleanup, set up a monitoring program, or organize a media campaign to make others in your community more aware of the problems facing a local waterway. Here are some organizations to contact for more information:

- Adopt-A-Stream Foundation, c/o Tom Murdoch, Executive Director, Box 5558, Everett, WA 98201. (Send a stamped, self-addressed, legal-size envelope.)
- Save Our Streams, Izaak Walton League, 1401 Wilson Blvd., Level B, Arlington, VA 22209.
- GREEN (Global Rivers Environmental Education Network), School of Natural Resources, The University of Michigan, Ann Arbor, MI 48109-1115.

contour map. For this activity, the kids can assume that your community is in the watershed of the nearest stream.)

2. Use a colored pencil or marker to trace the stream or river downstream until it joins a larger river. Use the same colored pencil or marker to trace the stream upstream as far as you can and to trace all the tributaries that dump into the river or stream all along its length.

3. Use a different colored pencil or marker to trace other streams and rivers in your area.

4. Outline the watershed you live in. (Remind the kids that the watershed they live in is made up of all the land that drains into the nearest stream or river. So, to outline the watershed, they should be outlining the land surrounding the nearest waterway and all its tributaries.)

Afterward discuss the following questions as a group. (See the background information on pages 56-58 for more about the effects of particular water pollutants.)

- What types of things do rainwater and snowmelt flow over in your area? (rooftops, sidewalks, roads, agricultural land, lawns, golf courses, and so on)
- What kinds of pollutants might rainwater or snowmelt pick up as they flow through your area? (Rainwater and snowmelt that run over streets, parking lots, fertilized yards, construction sites, and so on, often pick up toxic chemicals, silt, and other pollutants. The water then flows into storm drains that empty into rivers. And water running off agricultural land often contains high amounts of animal waste, pesticides, fertilizers, dirt, and other pollutants.)
- In what other ways might your community affect water quality? (some industries dump pollutants directly into rivers; pollutants from overflowing sewage treatment facilities may wash directly into waterways; pollutants from landfills or dumps may leach into water supplies; and so on)
- Which nearby communities might be affected if your community dumped untreated sewage into the nearest stream or river? (those downstream) Which communties could affect water quality in your community? (those upstream)

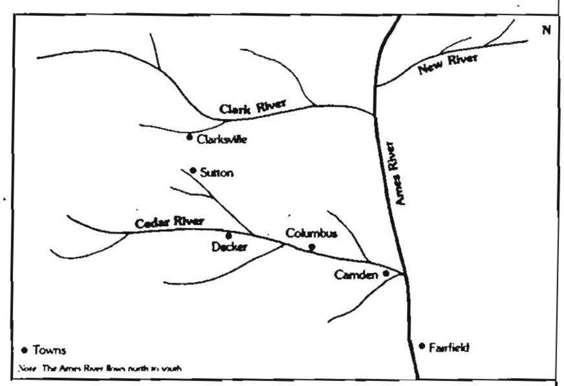
Finally, ask the kids what happens to the oil splotches you talked about in the beginning of the activity. (the oil may wash into your local stream or river and be carried downstream)

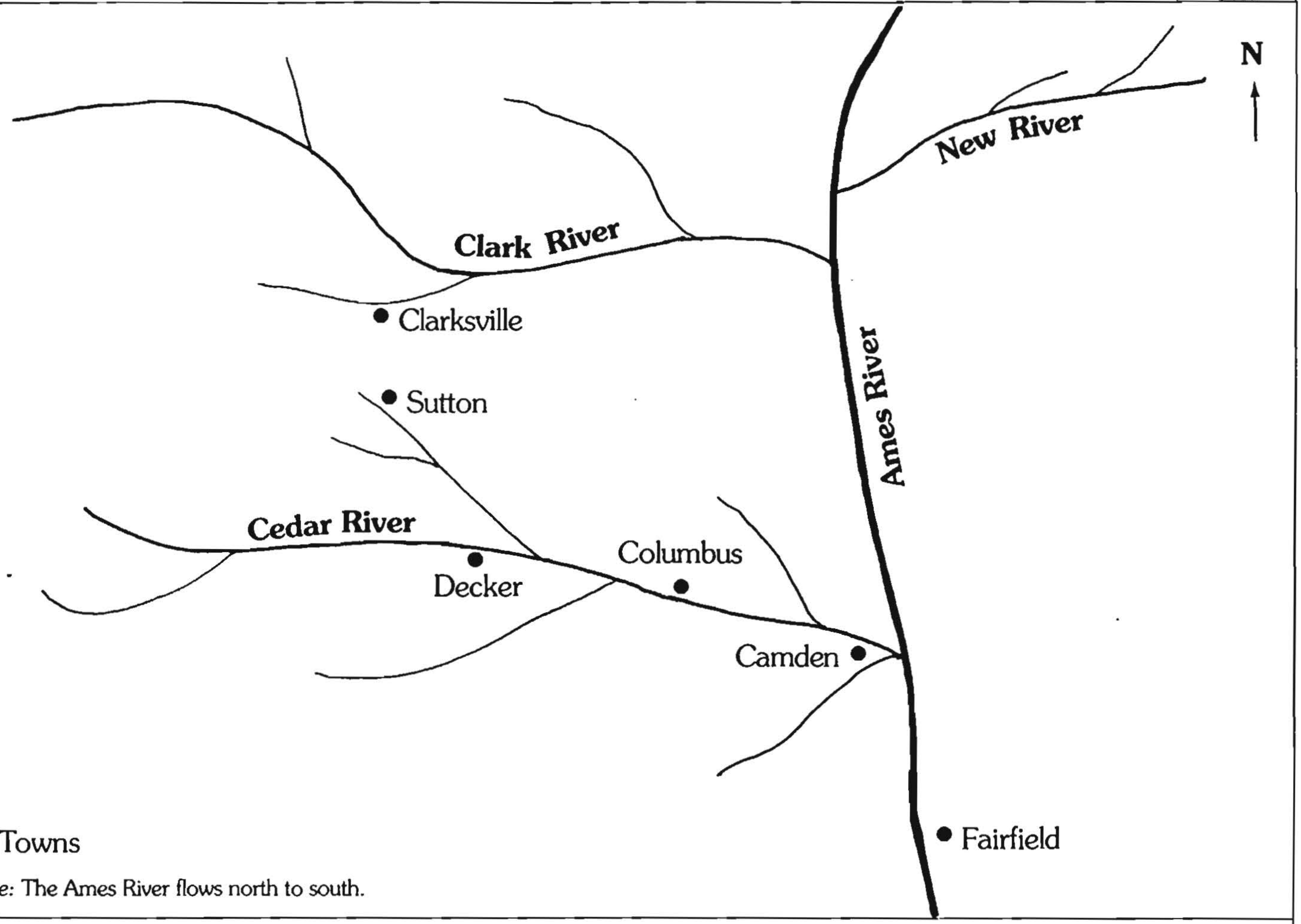
(This activity was adapted from *Conserving America, Rivers Resource Guide,* © 1988 by the National Wildlife Federation and WQED/Pittsburgh.)

ANSWERS

1—see diagram below
2—Ames River watershed, Clark and New
3—Columbus, Camden, and Fairfield because they are downstream from Decker
4—Cedar River, then into Ames River; Clark River, then into Ames River. Because Sutton is closest to the Cedar River and Clarksville is closest to the Clark River. However, they could be in the same watershed, depending on the slope of the land. For example, if a mountain or hill separated Clarksville from the nearby stream, wastewater from Clarksville could flow into the Cedar River watershed. It's more likely though, that Sutton is part of the Cedar River watershed and Clarksville is part of the Clark River watershed. (*Note:* They are both in the same larger Ames River watershed.)
5—Many of the pollutants carried by the Ames and the two other rivers—pollutants that were collected from large areas of land—would end up in Lake Churchill; as pollutants accumulate in Lake Churchill, water quality could decrease significantly and aquatic plants and animals could be affected.

Explain that as rivers empty into bays, lakes, and other bodies of water, some of the waste they're carrying can accumulate in these areas. This accumulation can create big pollution problems. For example, the Chesapeake Bay and the Great Lakes are suffering from the accumulation of pollutants flowing into them.





Note: The Ames River flows north to south.

1. Find the Cedar River and all the Cedar's *tributaries*—the smaller streams and rivers that flow into it. Then outline the Cedar River watershed.

2. What larger watershed is the Cedar River watershed a part of? What other rivers are part of this watershed?

____

3. There's a chemical manufacturing plant in Decker that dumps its waste into the Cedar River. What communities might be affected by this waste? Explain your answer.

____

____

4. Which river would animal waste and other pollutants from farms near Sutton wash into? What about from farms near Clarksville? Why would you think that Sutton and Clarksville are in two different watersheds? Is it possible for Sutton and Clarksville to be in the same watershed? Explain your answer.

____

____

5. Eventually the Ames River empties into Lake Churchill. Two other large rivers also empty into Lake Churchill. What effect might these three rivers have on conditions in the lake?

____

____

The Water Cycle

Interest Approach:
"Can anyone tell me, how important is water? What do we use it for?"
(possible student responses)

a. We drink it.
b. Animals need clean water to stay healthy.
c. We use water to clean ourselves.
d. Water is used in recreation.
e. The majority of the world consists of water.

"Where does water come from?"

a. the kitchen sink
b. rain, from the sky
c. rivers, lakes, oceans

The Water Cycle:
You know that when you hang clothes out on a line to dry, they dry. Where does this water go?

(Follow through the water cycle with the students as it is being discussed.)

A. The water turns into water vapor.
   1. caused by the sun's energy and by the action of wind
   2. water vapor is little drops of water which float in the air
   3. sometimes you can see water vapor
      a. steam
      b. fog

B. The process of water disappearing and turning into water vapor is referred to as evaporation.
   1. water evaporates from: oceans
      lakes
      rivers
      ground
      plants

C. water vapor that has evaporated travels up into the sky and cools down, there it makes clouds.
   1. clouds are made of millions of little drops of water
   2. sometimes these drops join together to make bigger drops
   3. this process is called condensation
      examples of: glasses fog up when walking inside
      fogged up car windows

D. When the drops get too big and heavy to stay up in the air, they fall down to the ground as precipitation.
   1. what are some forms of precipitation? rain
      snow
      ice
      hail

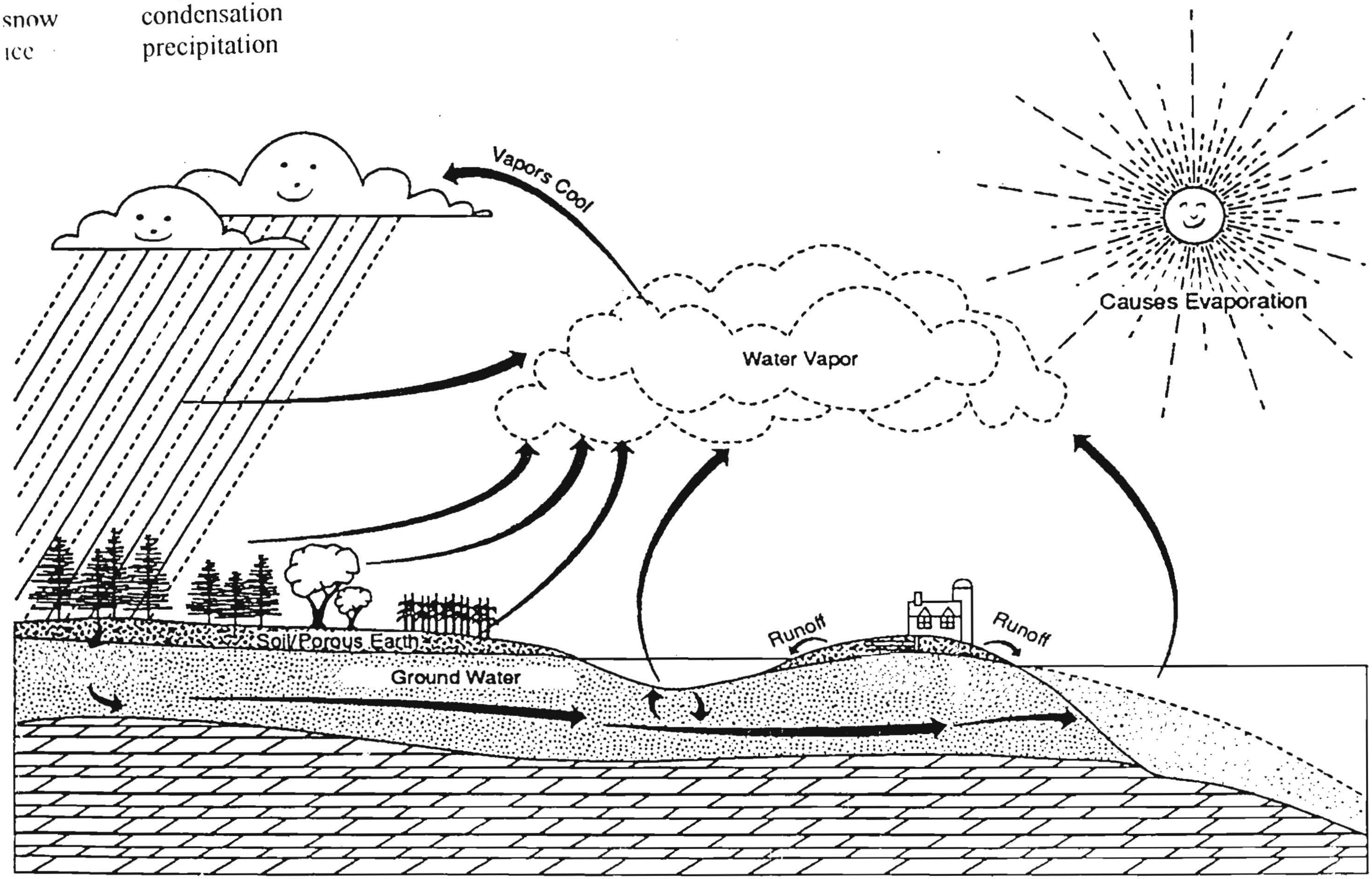
E. The water comes down to the ground and
   a. soaks in
   b. evaporates
   c. is used as drinking water for humans, plants, animals
   d. wears away rock to make soil
   e. flows into river-lakes-oceans
   f. process starts all over again

And, that's the water cycle. The process keeps repeating its self over and over.

Words to use:

ocean	sun's energy
lake	clouds
rain	evaporation
snow	condensation
ice	precipitation

The Water Cycle



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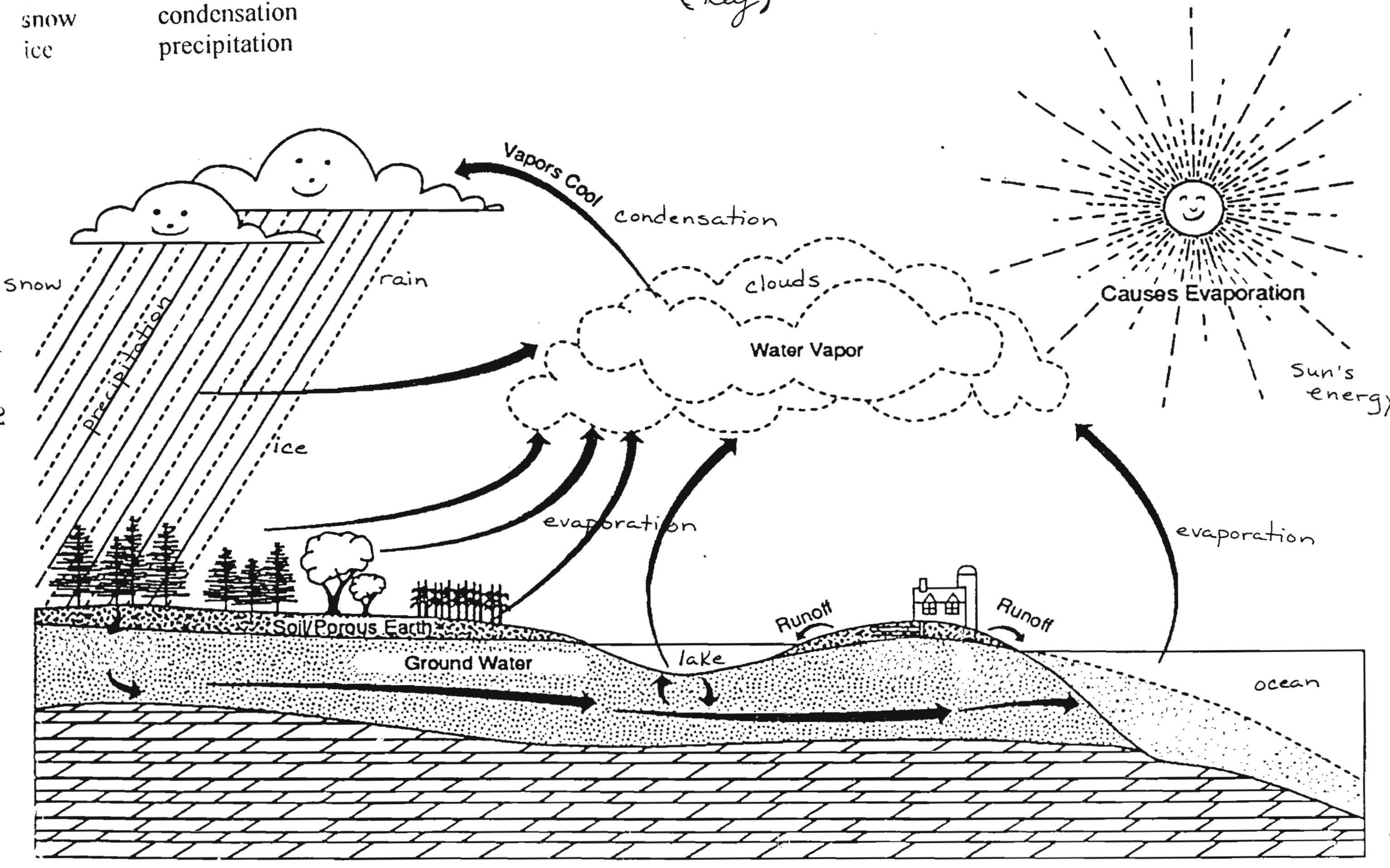
Words to use:

ocean	sun's energy
lake	clouds
rain	evaporation
snow	condensation
ice	precipitation

The Water Cycle

(Key)



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AQUATIC INSECTS

Most of us are familiar with fish, snails, tadpoles, and other aquatic animals, but few of us give a second thought to the many insects which live in the water. Any fisherman who has used real or simulated aquatic insects for bait recognizes the importance of these animals in the aquatic food chain.

Some aquatic insects, such as dragonflies and water striders, are relatively familiar. Others, like water scorpions, stoneflies, dobson-flies, and backswimmers, are known only to naturalists and ardent fishermen. Many pests, such as mosquitoes, blackflies, deer-flies, and horseflies are, unfortunately, familiar to everyone.

Many of the common orders of terrestrial insects, such as the beetles, bugs, flies and even moths, have aquatic relatives. Other groups, such as stoneflies, dragonflies and damselflies and mayflies, are made up entirely of aquatic species. Most of these insects are aquatic during only part of their life cycles, usually the larval and pupal stages. Others, such as some water bugs and water beetles, spend their entire lives in the water. Some aquatic insect larvae are provided with gills, while others must come to the surface to breathe. All aquatic adult insects must breathe air, although some can obtain a part of their oxygen from the water.

Common aquatic beetles are whirligig beetles, which spin about madly on the surface of the water; predacious diving beetles, both the young and adult of which prey upon other aquatic animals; and water scavenger beetles, with predacious larvae.

Water bugs are all air-breathers and nearly all predacious, the water-boatmen being the only vegetarians in the lot. Included in this group are water-striders, giant water bugs, water scorpions, backswimmers, and several less common families.

Several types of flies have aquatic young. The mosquito is probably the best-known of these, but craneflies, which look like giant mosquitoes, blackflies, midgets, horseflies, deerflies, and others are also included. The larva of the drone-fly, a flower-fly which resembles a honeybee, has a long, thin, tail-like air tube which has earned its common name of "rat-tailed maggot."

Lily-leaf caterpillars are the aquatic larvae of moths, and are commonly found among water-lily plants, living in cases made from leaf sections. These are the only common aquatic representatives of this order of insects.

The nymphs of stoneflies are found in swift-running streams, and the adults are often found under nearby bushes. Mayflies are found throughout Ohio, but occur in greatest numbers along Lake Erie. Dobson-fly larvae, or hellgrammites, are commonly found under stones or logs, and make excellent bait for bass and other fish. The larvae of caddis-flies build cases for themselves from pebbles, sand, twigs, and other debris, and spin silk-like nets which capture their food. Dragonflies and damselflies are closely related, and both nymphs and adults are predacious, eating great numbers of mosquitoes.

We have mentioned only a few of the many kinds of aquatic insects. Their importance is now widely recognized, and they are given some protection by state laws. Without the aquatic insects, we would surely have few fish, frogs, or water-birds. In addition, the study of aquatic life would be much less interesting if these fascinating creatures were removed.

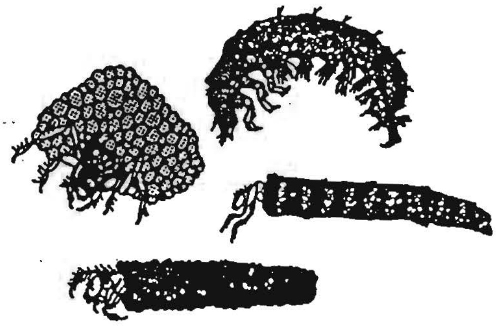
MACROINVERTEBRATE IDENTIFICATION GUIDE

GROUP ONE TAXA - pollution sensitive organisms

Caddisfly larvae

Order Trichoptera

Key features:
- "worm-like" appearance
- 6 legs near head
- small tail hooks
- size range: 1/4" - 3/4"
- may be found in case

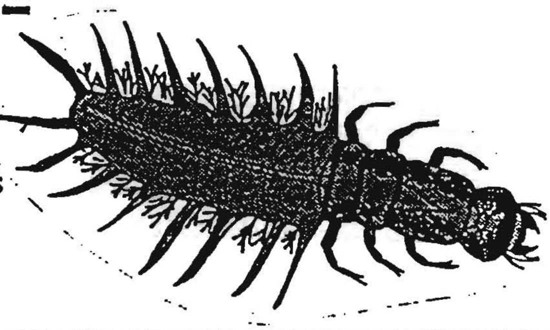


Caddisfly larvae can often be found on the undersides of stones, protected by a collection of small pieces of stone, shells, or other materials which are held together by an adhesive substance that caddisfly larvae secrete. They may also be found in cylindrical cases which they make and wear for protection. They will retract into this case when threatened or startled. Body color of these larvae varies from yellow and green to brown. Note: These larvae tend to curl up slightly (as pictured) when placed on a flat surface.

Dobsonfly larvae

Family Corydalidae

Key features:
- set of "pincers"
- tail hooks
- stout body with 6 legs
- lateral appendages
- with gills underneath
- size range: 3/4" - 4"

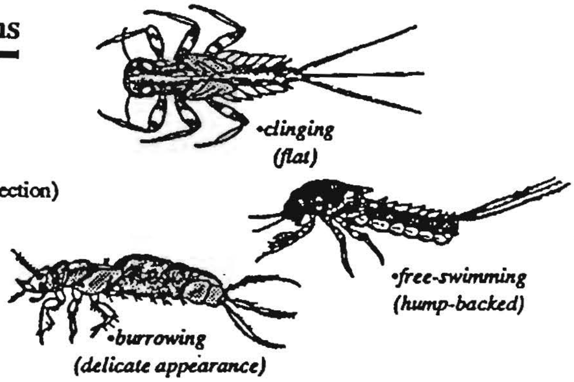


Dobsonfly larvae are often found clinging to rocks in the more swift areas of the riffle. These larvae are predacious and spend much of their time hunting for prey. They have stout bodies with tough skin. The appendages on the rear section of this organism are called "lateral appendages" and should not be mistaken for legs. If you find a dobsonfly larva in your seine, grasp it directly behind the head to pick it up. This makes it impossible for the larva to pinch you. Note: These larvae are also known as "hellgrammites."

Mayfly nymphs

Order Ephemeroptera

Key features:
- 3 hair-like tails (these may break off during collection)
- 6 legs
- 3 basic types (pictured at right)
- size range: 1/4" - 1"

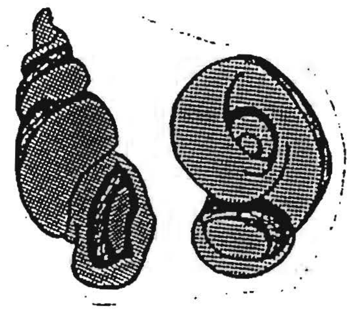


The three basic types of mayfly nymphs are classified by their life style. Burrowing nymphs burrow in the stream bottom sediments and are typically longer and lighter in color than the other types of mayfly nymphs. Clinging nymphs have very long, fragile tails, and are typically brown like the rocks they "cling" onto. Free-swimming nymphs are fast swimmers and are usually dark colored. Colors among these three groups vary, but tan, brown and black are common. All three types share the characteristic of three tails, though tail length may vary. Note: Tails are most easily seen on a submerged organism.

Other snails

Class Gastropoda

Key features:
- shell opens to the right (see text)
- on most, a covering, called the operculum, indicates the snail is alive. If no operculum is present look for a fleshy "foot."

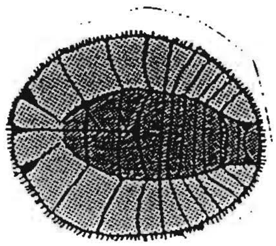


Snails in this category can be distinguished from pouch snails by the opening of the shell. To identify a snail, hold it with the tip of the shell pointed up and the opening facing you (as pictured). If the opening is to the right side, you have a snail that falls in the "other snails" category, also referred to as the "gill-breathing" snails. Note: The flat, coiled snails also fall in this group. Do not count empty shells.

Water penny beetle larvae

Family Psephenidae

Key features:
- very flat
- oval or round in shape



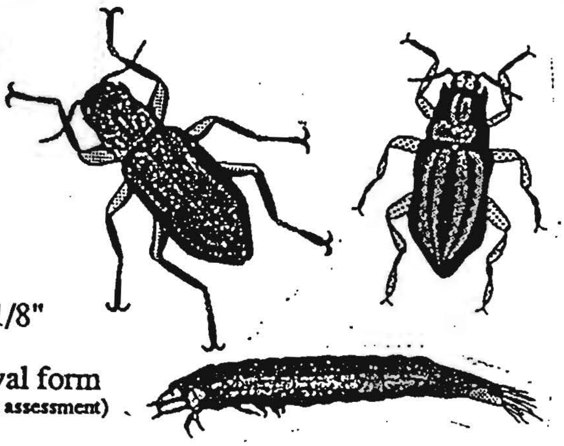
Water penny beetle larvae look like fossils as they cling to the undersides of rocks. These larvae are tan, brown, or black and round like a penny (though smaller). They are flat and have six small legs on their undersides. They are best found by direct inspection of rocks at the river's edge.

GROUP ONE TAXA (continued)

Riffle beetles

Family Elmidae

Key features:
- very small
- 6 legs
- size range: 1/16" - 1/8"
- may be found in larval form (this form is not counted in the assessment)

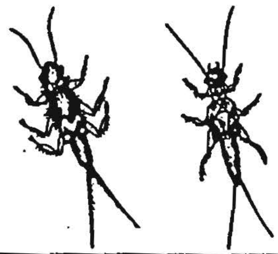


***Riffle beetle adults** are very small and hard to spot because they are dark colored (usually black) and blend in well with chips of slate and dead leaves in the seine. To find these beetles, watch the seine closely for movement. Be careful not to mistake small terrestrial beetles for riffle beetles. If you are uncertain if you have a riffle beetle or a terrestrial beetle, put it in water. If it seems well adapted to water and fits the rest of this description, it is probably a riffle beetle. Please be aware of the appearance of the larval form so you do not confuse it with other organisms. Note: the larval form's hard exterior, cylindrical shape and the small tuft of white filaments which are present at the rear of the organism.*

Stonefly nymphs

Order Plecoptera

Key features:
- two tails
- 6 legs
- size range: 3/16" - 1"



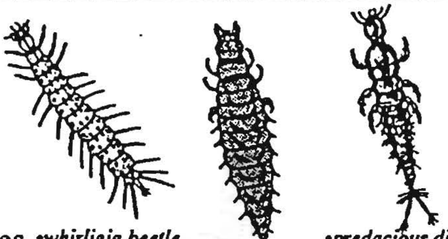
***Stonefly nymphs** are structurally similar to mayfly nymphs, except that stonefly nymphs have two tails instead of three. They also appear somewhat less fragile than mayflies, because they possess a more rigid-looking exterior. They are often yellowish and brown or black in color and may be brilliantly patterned.*

GROUP TWO TAXA - pollution intermediate organisms

Beetle larvae

Order Coleoptera

Key features:
- head more slender than that of the dobsonfly
- 6 legs
- some with lateral appendages
- size range: 1/2" - 1"



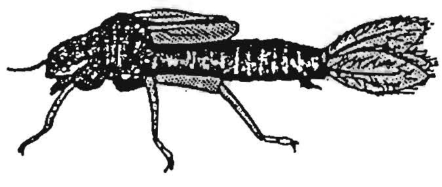
•whirligig beetle larva *•water scavenger beetle larva* *•predacious diving beetle larva*

***Beetle larvae** look somewhat similar to dobsonfly larvae, but are generally smaller, lighter in color an more slender and tapered than the dobsonfly larvae. Often the head is darker in color than the rest of the body. Beetle larvae will not have the pronounced pincers that the dobsonfly larvae possess. The appendages on the back section (abdomen) of this organism, if present, are called "lateral appendages" and should not be mistaken for legs.*

Damselfly nymphs

Order Odonata

Key features:
- 6 legs
- 3 feathery tails
- size range: 1/4" - 3/4"



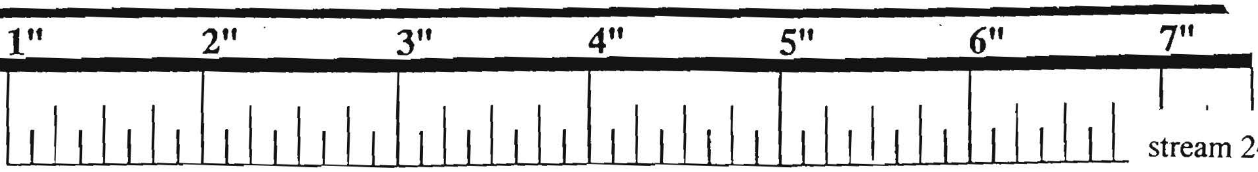
***Damselfly nymphs** are somewhat slender, with six legs and three feathery tail appendages which are flat or fan-like and usually oval in shape. These tails are readily visible if the organism is placed in water. Damselfly nymphs are most easily found around stream vegetation and calmer areas along the stream's edge.*

Dragonfly nymphs

Order Odonata

Key features:
- large eyes (like adult dragonfly)
- 6 legs
- often flat on underside
- no tails
- size range: 1/2" - 1 1/2"

***Dragonfly nymphs** have the large eyes typical of the adult form and are often quite flat on their undersides. The abdomen may be stout and somewhat diamond-shaped. These nymphs do not have tails like those seen on the damselfly, mayfly, or stonefly nymphs. The body length may be up to 1", and the legs may be quite long. Some may look "spider-like". Like damselfly nymphs, they are most easily found near aquatic vegetation or in the calmer areas of the stream.*



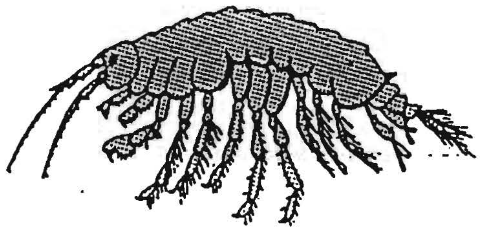
Ruler

Inches

Scuds

Order Amphipoda

Key features:
- "shrimp-like"
- usually quite small
- size range: 1/8" - 1/4"

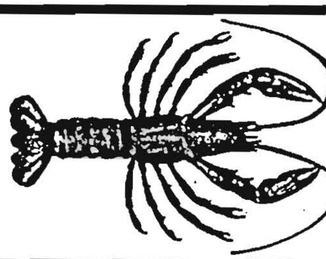


Scuds look basically like little shrimp and they actually belong to the same subphylum, Crustacea. They have a swimming motion similar to that of crayfish, propelling themselves backwards through the water with quick strokes of their tails. They may be slightly orange or green and are somewhat translucent and shiny with some silvery-gray coloration.

Crayfish

Order Decapoda

Key features:
- 10 legs, 2 with claws (unless broken off)
- size range: 1/2" - 5"

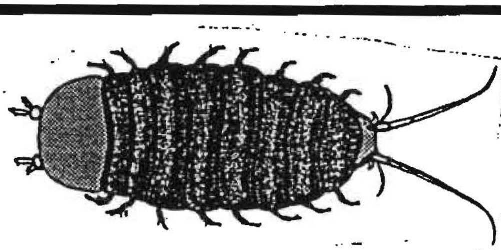


Crayfish are quite easy to identify. They closely resemble a small lobster. They can be found under loose rocks in the middle or the edge of the riffle. They will swim swiftly backwards if frightened or disturbed. Note: Crayfish are also known as crawdads.

Sowbugs

Order Isopoda

Key features:
- segmented, flat body
- many legs
- size range: 1/4" - 1/2"

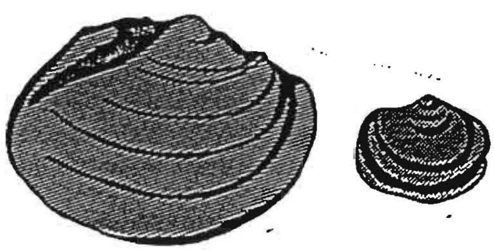


Sowbugs are gray and segmented, with an "armored" appearance. They look very similar to terrestrial sowbugs, also known as pill bugs. They have a sort of rectangular shape and many small legs. Sowbugs are most easily found along the stream's edge.

Clams

Class Bivalvia (Pelecypoda)

Key features:
- 2 hinged shells
- fleshy "foot" (not visible if shells are closed tightly)
- size range: 1/8 - 5"

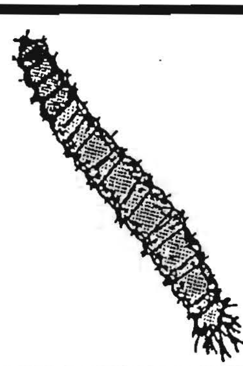


Clams are easily identified by their two shells which they will draw tightly closed when handled. Count only whole, live clams (those with both shells) in your assessment. Please do not force the shells open to see if you have a live clam. If the shell is tightly closed, you can assume the organism is alive. Note: Clams are usually buried in the stream bottom, so you should kick up the sampling area thoroughly. Also, as indicated by the size range, clams can be quite small and fragile, so look carefully and handle carefully. Do not count empty shells.

Crane fly larvae

Family Tipulidae

Key features:
- worm-like and plump
- no legs
- small tentacles at one end (these will extend if you give the larvae a gentle squeeze)
- size range: 1/2" - 2 1/2"



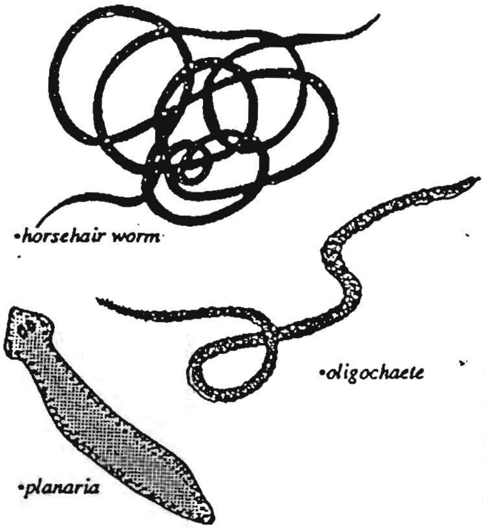
Crane fly larvae are segmented and worm-like. They can be found in a large variety of colors, including white, brown, and green. Some are almost translucent, so you can see the insides of the organism move when it crawls. These larvae have a soft, fleshy appearance and very short tentacles (small "arms" or projections) at one end which can be seen more easily if the larvae is placed in water or squeezed gently. They range in length from 1/2" to 2 1/2" and may be as thick or slightly thicker than a pencil.

Please note: If you find an organism which you cannot identify with this guide, please feel free to draw a sketch of it on the back page of our assessment form (please make a note on the front to direct our attention to the back of the page). We will then attempt to identify the organism at the office and contact you to let you know of the correct identification.

GROUP THREE TAXA - pollution tolerant organisms

___ Aquatic worms
Phylum Annelida and others

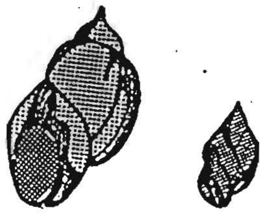
Key features:
- no legs
- may be smooth or bristly
- may be round or flat
- size range: 1/4" - 5"



Many aquatic worms look similar to earthworms. In streams, you may also find very long, slender worms (such as horsehair worms), or flatworms, like planaria, which are small, sticky and soft-bodied (contrast with the muscular leech--see below). Many of these can slip through the seine quite easily, so watch closely. If you locate a worm and it is not a midge larva, crane fly larva, leech, or black fly larva, (see descriptions below and on previous page) it should be recorded under the category of "aquatic worms." These worms will typically "wriggle" in a snake-like fashion. Colors vary greatly in this category (red, white, and brown are common). Note: Worms do not have legs. If it looks like a worm, but has six legs (they may be small) it is not an aquatic worm -- check the other descriptions to correctly identify the organism.

___ Pouch snails
Class Gastropoda

Key features:
- shell opens to the left
- presence of a fleshy "foot" indicates the snail is alive.



Snails in this category can be distinguished from "other snails" by the opening of the shell. To identify a snail, hold it with the tip of the shell pointed up and the opening facing you (as pictured). If the opening is to the left side, you have a pouch snail. Do not count empty shells.

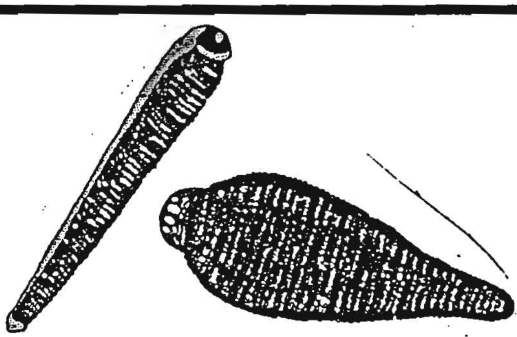
___ Black fly larvae
Family Simuliidae

Key features:
- quite small
- bulbous at one end
- constricted in middle
- size range: 1/16" - 1/4"

Black fly larvae are small and slightly bulbous at one end. They use this bulbous end to attach themselves to rocks and other material, usually in the faster flowing areas of the riffle. They may be found in groups, attached to stones and leaves and will often curl into a "u" shape when pulled off and held in the hand. Most larvae are gray or brownish in color.

___ Leeches
Class Hirudinea

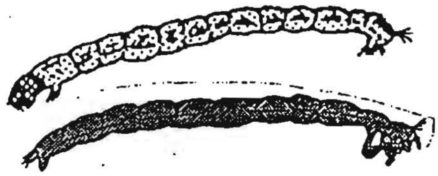
Key features:
- flat underside
- circular, sucking mouth
- size range: 1/2" - 4" when extended (see text)



Leeches are usually small, dark in color, and flat. They tend to cling to smooth stones and boulders with their circular "sucker." Leeches generally have the appearance of being segmented, with the lines running perpendicular to the length of their body. They may be long and tapered, or short and tear-drop shaped. They move by extending and contracting their tough muscular bodies, so they may appear quite long. Do not confuse these with the flat, soft-bodied planaria (see above).

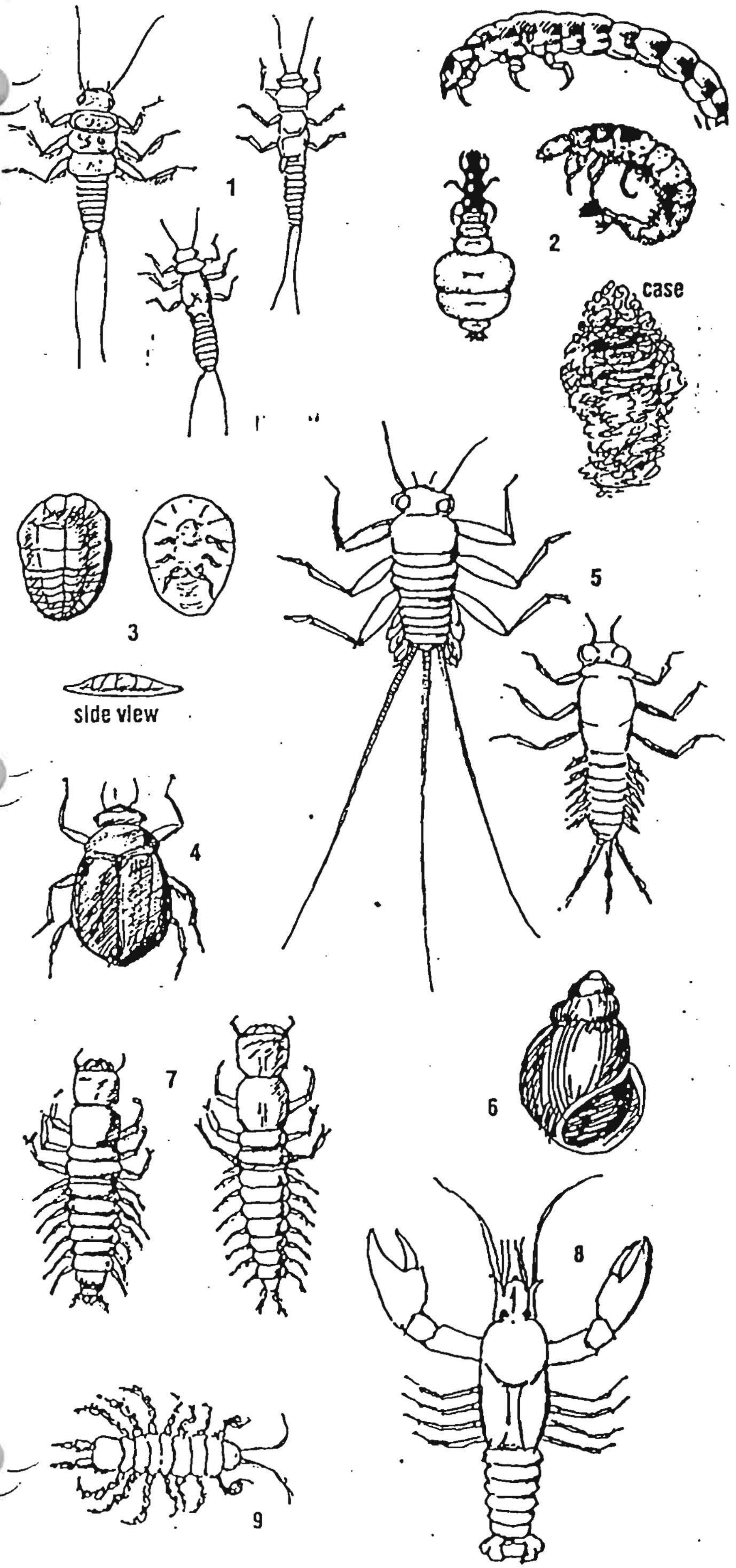
___ Midge larvae
Family Chironomidae

Key features:
- often very small, slender
- spastic squirming action (see text)
- size range: 1/8" - 1/2"



Midge larvae are often a distinct red color, though they can also be brown or even whitish in color. The best way to identify these larvae is by their small size and spastic squirming action. Note: These are very small, slender organisms, so watch your seine closely and make a point of inspecting leaves and other debris which may be present.

This identification sheet was designed by the staff of the Division of Natural Areas and Preserves with assistance from volunteer Anne Coburn for use with the Ohio Scenic Rivers Stream Quality Monitoring Program. Our thanks to Anne and to all our dedicated volunteers.



Stream Insects & Crustaceans

GROUP ONE TAXA

Pollution sensitive organisms found in good quality water.

1 *Stonefly: Order Plecoptera* 1/2" - 1 1/2", 6 legs with hooked tips, long antennae, 2 hair-like tails. *Three examples.*

2 *Caddisfly: Order Trichoptera* Up to 1/2", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. *Four examples.*

3 *Water Penny: Oder Coleoptera* 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs on the other side. Immature beetle. *Three examples.*

4 *Riffle Beetle: Order Coleoptera* 1/4", oval body covered with tiny hairs, 6 legs, antennae.

5 *Mayfly: Order Ephemeroptera* 1/4" - 1", brown, moving, plate-like gills on sides of body, 6 large hooked legs, many long feelers on lower half of body, antennae, 2 or 3 long, hair-like tails. *Two examples.*

6 *Gilled Snail: Phylum Mollusca* Shell opens on right, opening covered by thin plate called operculum.

7 *Dobsonfly (Hellgrammite): Suborder Megaloptera* 3/4" - 4", dark-colored, 6 legs, many long feelers on lower half of body, short antennae, 4 hooks at back end. Contains fan-shaped gill tufts along sides. *Two examples.*

GROUP TWO TAXA

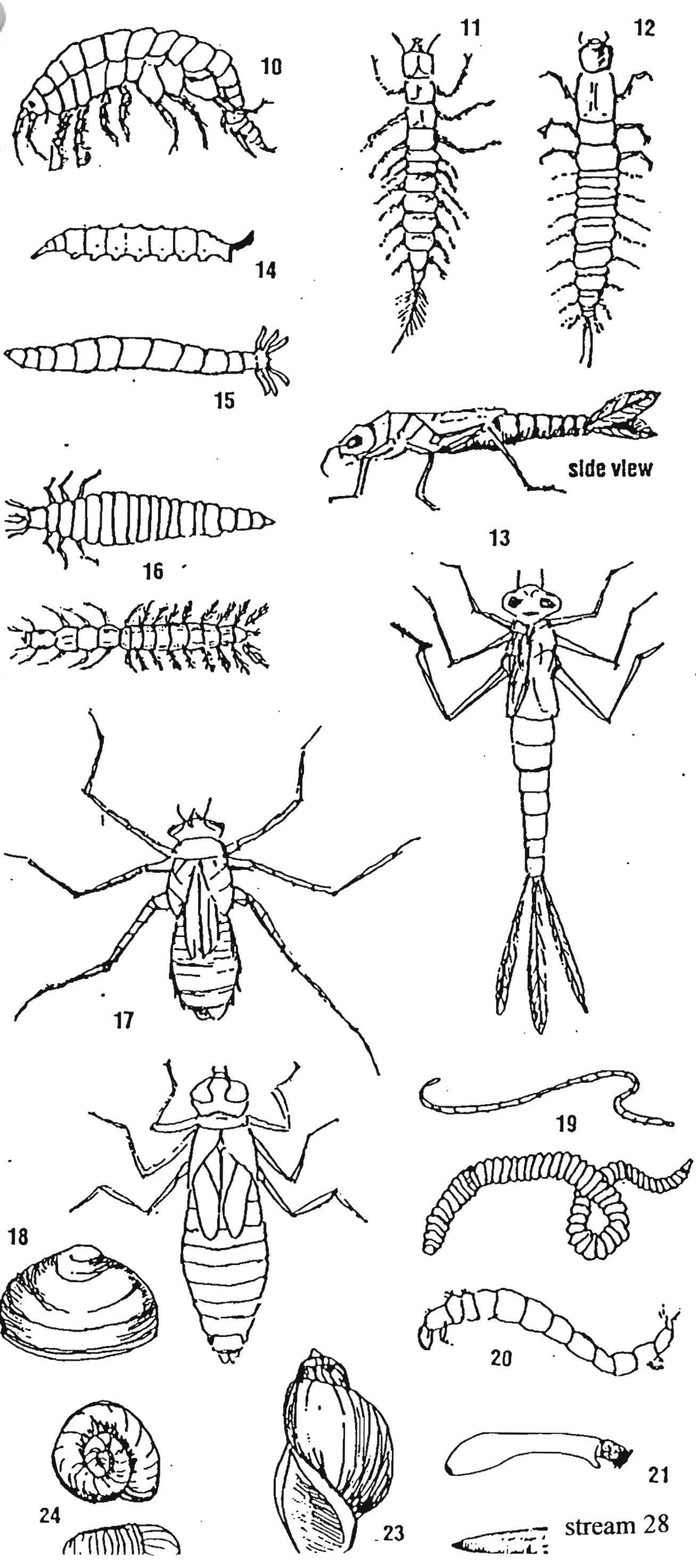
Somewhat pollution tolerant organisms can be in fair quality water.

8 *Crayfish: Order Crustacea* 1/2" - 6", 2 large claws, 8 legs, resembles small lobster.

9 *Sowbug: Order Crustacea* 1/4 - 3/4", gray oblong body wider than it is high, more than 6 legs, antennae.

Save Our Streams

Izaak Walton League of America
1401 Wilson Blvd. Level B
Arlington, VA 22209



GROUP TWO TAXA continued

10 *Scud: Order Crustacea* 1/4", fat body higher th. It is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 *Alderfly larva: Suborder Megaloptera* 1" long. Looks like small hellgrammite but has 1 long, thin, branched tail at back end.

12 *Fishfly larva: Suborder Megaloptera* 1" - 11/2" long. Looks like small hellgrammite but lighter reddish-tan color, often with yellowish streaks. Does not contain any gill tufts.

13 *Damselfly: Order Odonata* 1/2" - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails. *Two views*

14 *Watersnipe Fly Larva: Order Diptera (Atherix)* 1/4" - 3/4", green, tapered body, many caterpillar-like legs, conical head, feathery "horn" at back end.

15 *Crane Fly: Order Diptera* 1/3" - 2", green or brown, plump caterpillar-like segmented body, finger-like lobes at back end.

16 *Beetle Larva: Order Coleoptera* 1/4" - 1", light-colored, 6 legs on upper half of body, feelers, antennae. *Two examples*

17 *Dragonfly: Order Odonata* 1/2" - 2", large eyes 6 hooked legs. *Two examples*

18 *Clam: Phylum Mollusca*

GROUP THREE TAXA

Pollution tolerant organisms can be in poor quality water.

19 *Aquatic Worm: Order Oligochaeta* 1/4" - 1", can be very tiny, thin worm-like body.

20 *Midge Fly Larva: Order Diptera* Up to 1/4", worm-like segmented body, 2 legs on each side.

21 *Blackfly Larva: Order Diptera* Up to 1/4", one end of body wider. Black head, suction pad on end.

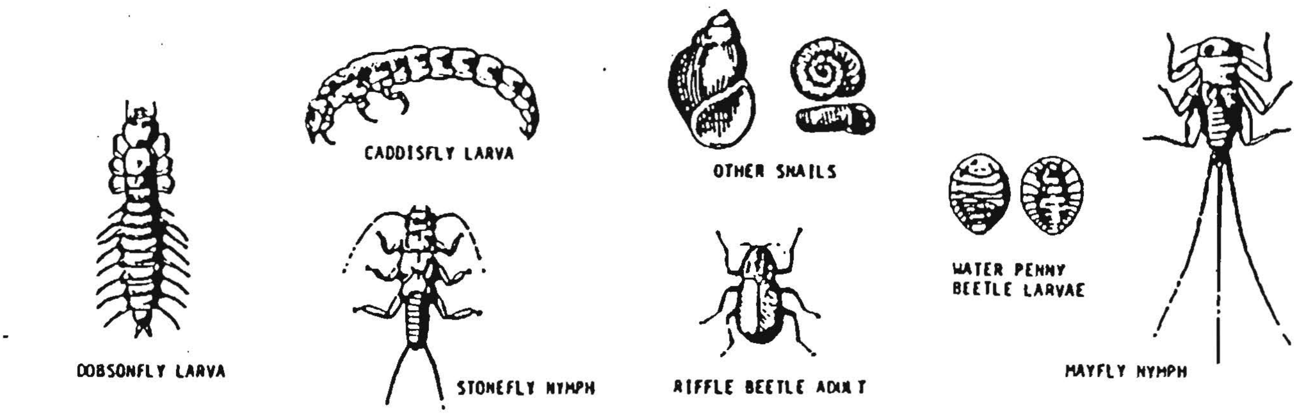
22 *Leech: Order Hirudinea* 1/4" - 2", brown, slimy body, ends with suction pads.

23 *Pouch Snail: Phylm Mollusca* Shell opens on left. No operculum. Breathe air.

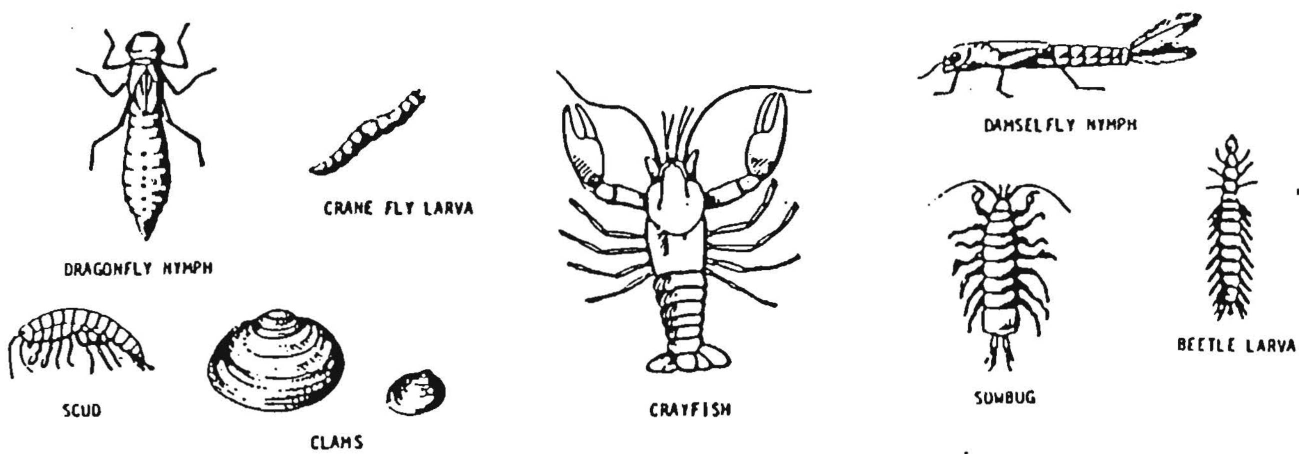
24 *Other snails*

MACROINVERTEBRATE TAXA GROUPS

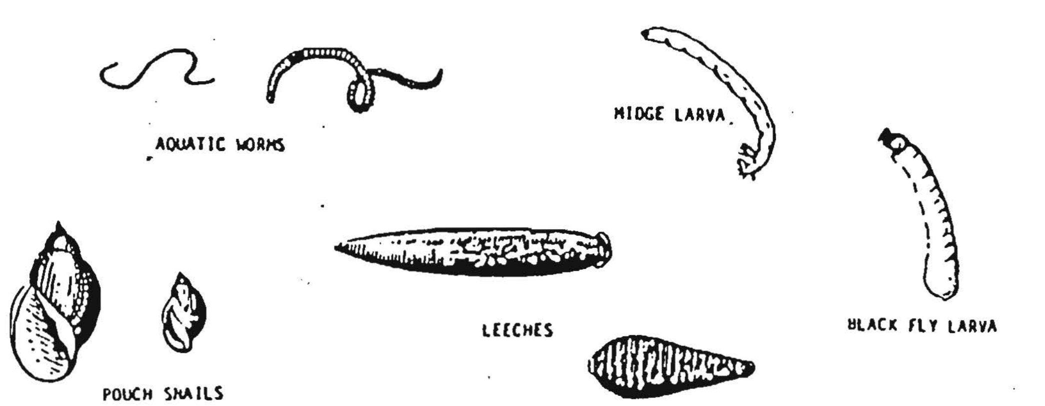
GROUP 1 *(These organisms are generally pollution-intolerant. Their dominance generally signifies GOOD WATER QUALITY)*

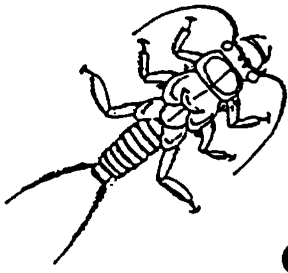


GROUP 2 *(These organisms can exist in a wide range of water quality conditions.)*



GROUP 3 *(These organisms are generally tolerant of pollution. Their dominance usually signifies POOR WATER QUALITY.)*





Creek Critter Walk

- Take a *walk for wildlife* along the stream and see how many of the "creek critters" you can find. The aquatic larvae or nymphs are the youth or juvenile stages of insects. In many cases the adult stages of these aquatic young are found on land (terrestrial).

- *Check the "critters" you find as you search in and along the stream and attempt to match the young with its adult counterpart. What type of stream quality will your "sample" indicate? Place an "x" on each kind you find. Place only one "x" per blank.*

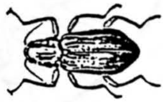
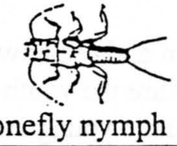
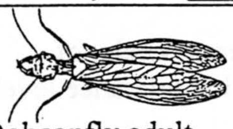
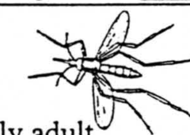
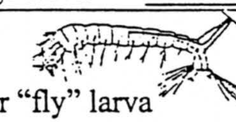
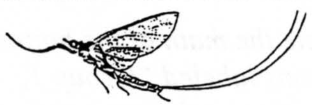
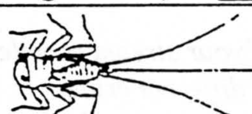
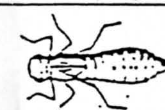
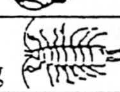
- Water quality can be determined from the diversity (number of different kinds) of organisms living in the stream. The chart below indicates the pollution tolerance level of various aquatic organisms.

- *To determine the water quality of your stream sample, complete the math at the bottom of the chart. Multiply the number of different critters in the columns labeled "Group 1, Group 2, and Group3" by the appropriate multiplier. Add the three columns together to get your stream quality index grand total.*

Delaware and Franklin Soil and Water Conservation Districts

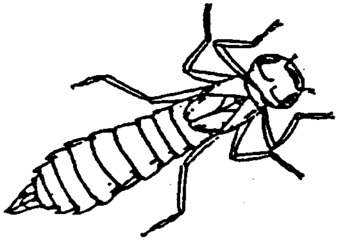
over

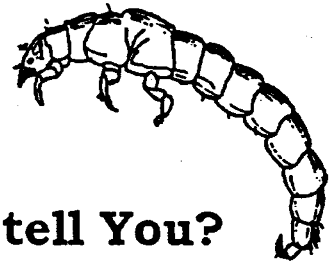
Stream Quality Assessment

	Group 1: live only in clean water		**Group 2:** can tolerate a little pollution		**Group 3:** can live in polluted water
 Water penny beetle adult ____	 Water penny beetle larva ____	 Cranefly adult ____	 Crane fly larva ____	 Blackfly adult ____	 Black fly larva ____
 Stonefly adult ____	 Stonefly nymph ____	 Beetle adult ____	 Beetle larva ____		 Aquatic worm ____
 Caddisfly adult ____	 Caddisfly larva ____		 Crayfish ____	 Midge adult ____	 Midge larva ____
 Dobsonfly adult ____	 Dobsonfly larva (Hellgrammite) ____		 Scud ____	 Fly adult ____	 Other "fly" larva (Diptera) ____
 Mayfly adult ____	 Mayfly nymph ____	 Damselfly adult ____	 Damselfly nymph ____		 Leech ____
	 Riffle Beetle Adult ____	Dragonfly adult  ____	 Dragonfly nymph ____		Pouch Snail  ____
	Gilled Snail ____ 		 Clam ____		Other snail  ____
			Sowbug  ____		
	Number of "X"s in Group 1 ____ x 3 Total: ____		Number of "X"s in Group 2 ____ x 2 Total: ____		Number of "X"s In Group 3 ____ X 1 Total: ____

Stream Quality Index: **Excellent > 22** **Good 17-22** **Fair 11-17** **Poor 0-11** **Grand total (of groups 1 + 2 + 3) =** ____________

over





What do "Creek Critters" tell You?

1. What is the quality of the water in this stream?

   excellent   good   fair   poor

2. Did you find a lower biodiversity and some different kinds of "critters" below the pipe than above?

   yes   no

3. Why?

What <u>you</u> do on land may affect the quality of streams and the "critters" which live there.

Be a watershed steward:
To take care of the water, you must take care of the land!

Contact your local Soil and Water Conservation District (SWCD) to learn how you can become a steward of our natural resources.

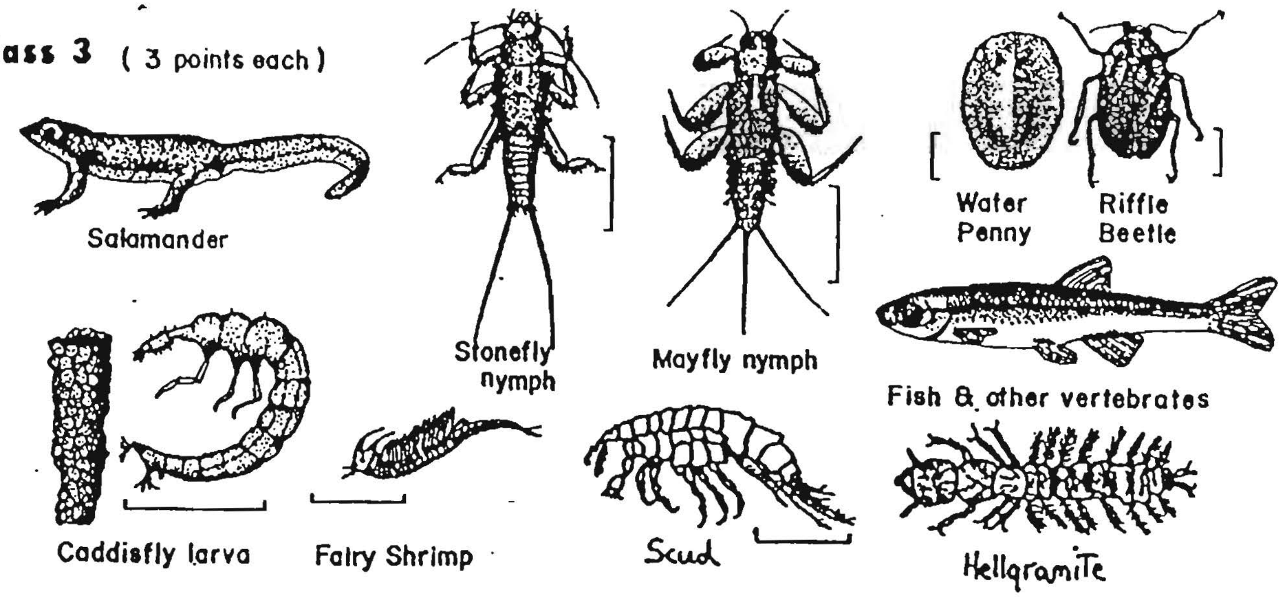
Delaware SWCD
557-A Sunbury Road (Rt. 36-37E.)
Delaware, OH 43015-8656
(740) 368-1921

Franklin SWCD
1945 Frebis Avenue
Columbus, OH 43206-3793
(614) 443-9416

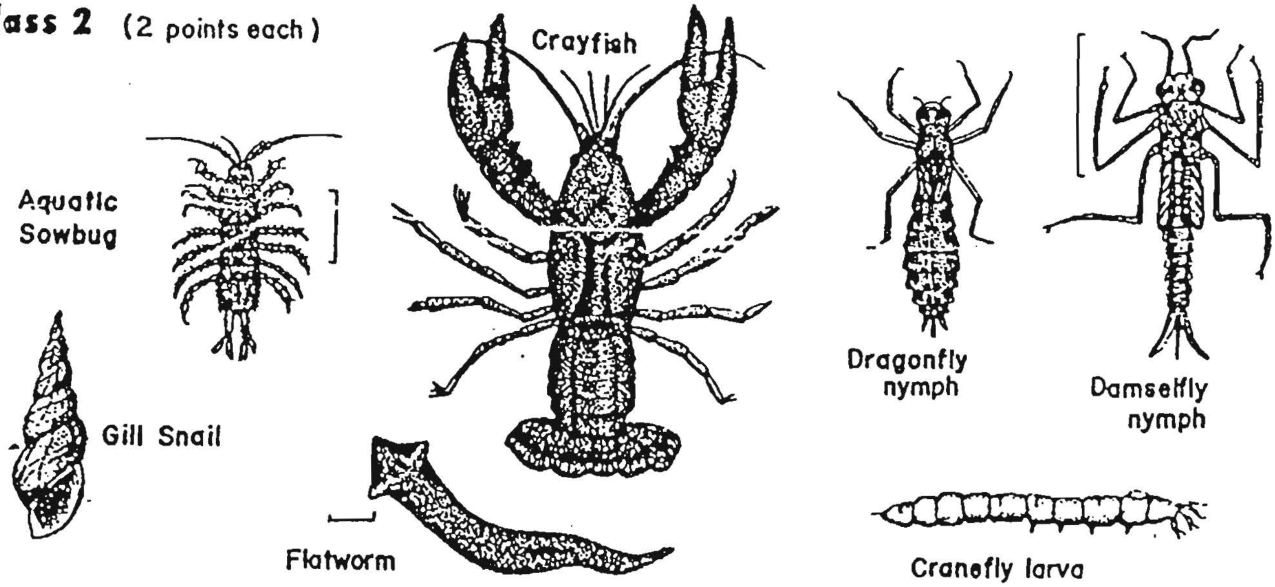
BIOTIC INDEX

Name ____________________

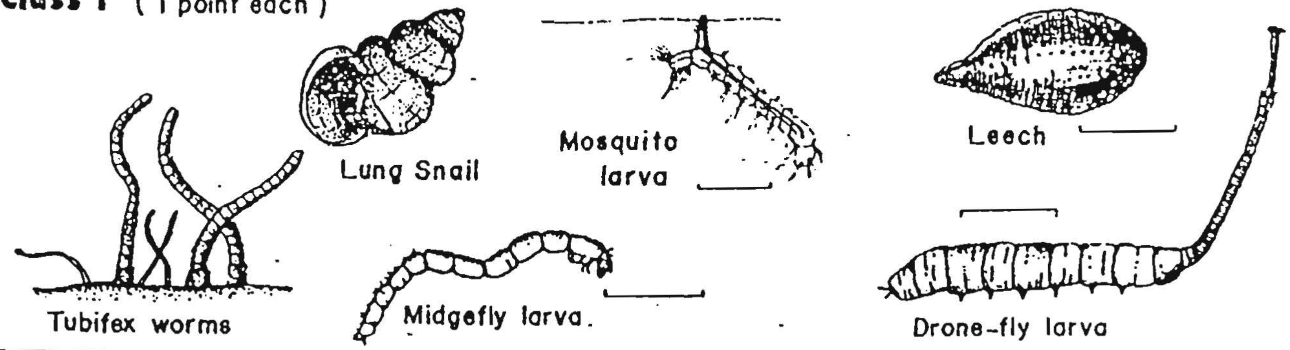
Class 3 (3 points each)



Class 2 (2 points each)



Class 1 (1 point each)



Total (for riffles)

Very clean ____________ 23-30

Clean ____________ 17-22

Not so clean ____________ 11-16

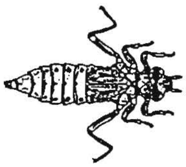
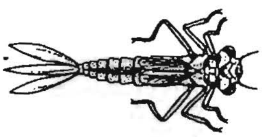
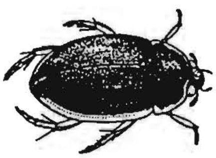
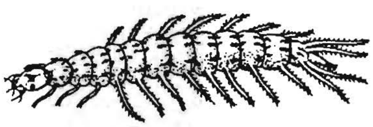
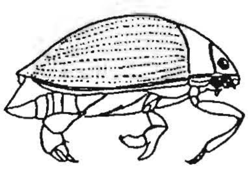
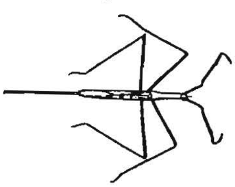
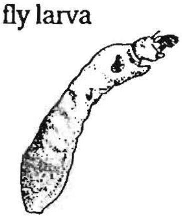
Polluted ____________ 5-10

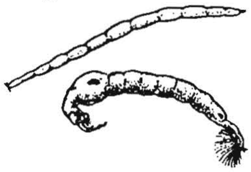
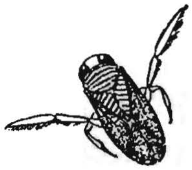
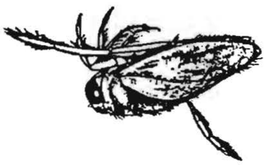
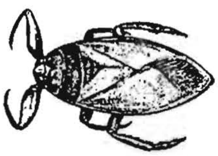
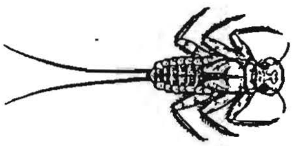
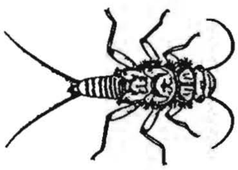
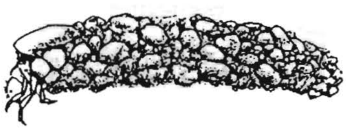
Bottom condition ____________

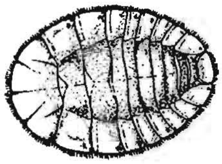
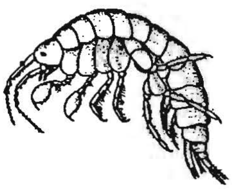
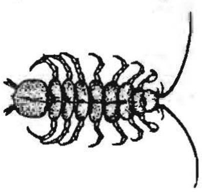
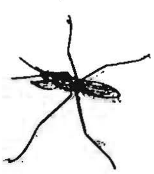
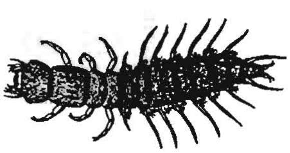
Water velocity ____________

Temperature ____________

Checklist of Common Aquatic Invertebrates

Aquatic Organism	Number Found in Pond	Number Found in Stream
Dragonfly nymph 		
Damselfly nymph 		
Water scavenger beetle adult 		
Whirligig beetle larva 		
Whirligig beetle adult 		
Water scorpion (adult) 		
Black fly larva 		

Aquatic Organism	**Number Found in Pond**	**Number Found in Stream**
Midge larvae 		
Water boatman (adult) 		
Backswimmer (adult) 		
Giant water bug (adult) 		
Mayfly nymph 		
Stonefly nymph 		
Caddisfly larva 		

Aquatic Organism	**Number Found in Pond**	**Number Found in Stream**
Crane fly larva 		
Water penny (beetle larva) 		
Scud 		
Aquatic sowbug 		
Mosquito larva 		
Water strider (adult) 		
Dobsonfly larva (hellgrammite) 		

Pollution Pursuits

Answer some pollution survey questions and play a pollution trivia game.

Objectives:
Discuss the connection between individual behavior and pollution. Describe several types of pollution and explain what causes each type. Explain how pollution affects people, wildlife, and the environment.

Ages:
Intermediate and Advanced

Materials:
- ***copies of the survey questions on page 10***
- ***trivia questions on pages 10-11***
- ***slips of paper***
- ***chalkboard or easel paper***
- ***index cards cut into 3-inch squares***
- ***sack***
- ***drawing paper or mural paper***
- ***crayons or markers***
- ***tape***

Subjects:
Science and Social Studies

Here's an activity that you can use to kick off *and* wrap up a unit on pollution. In Part 1 you can find out what your kids know and think about pollution by having them take a short survey. Then, by playing a trivia game in Part 2, the kids can review what they've learned.

PART 1: THE SURVEY

Pass out a copy of the survey questions under "What Do You Think?" on page 10 to each person. Tell the group that the questions deal with different aspects of pollution, and that you'd like them to answer the questions as honestly as possible. Explain that you want to find out what they know and think about pollution, but reassure them that it's not a test. (Some of the questions are more difficult than others. Adapt them to fit the needs of your group.)

After the kids have completed the survey, collect their answers and the questions. Explain that they'll get a chance to discuss the answers later on. You can use the kids' answers to help you decide what to cover during your pollution study.

After completing your pollution studies, pass out the survey questions and have the kids answer them again. Then pass out their original responses and have the kids compare their answers. Ask them how their answers changed, if at all. Then discuss why they think their answers changed.

PART 2: WHAT'S YOUR POLLUTION IQ?

Your kids can play a team game that will help them review—and tie together—all they've learned about pollution. Here's how to set up and play the game:

Getting Ready

1. Write the numbers 1-52 on separate slips of paper and put the slips in a sack. Also include five slips with an "X" marked on each one and five slips with an "O" marked on each one.

2. Divide the group into three teams and give each team a sheet of drawing paper or mural paper and some crayons or markers. Assign one team to be air pollution, one to be water pollution, and one to be land pollution. Explain that, as a group, each team should draw a scene that is affected by the type of pollution they've been assigned. Tell them to make their drawings as detailed as they'd like and at least 11" X 17".

3. Copy the following list of pollutants on a chalkboard or sheet of easel paper. Have each team make two sets of pollutant cards by copying each of the pollutants listed under each team's name onto two separate 3-inch square cards. (There should be a total of 12 pollutant squares for each team.) Then have the kids on each team "pollute" their scene by taping the 12 pollutants on their drawing.

AIR: carbon dioxide, acid rain, CFCs, smog, particulates, carbon monoxide
WATER: lead, mercury, PCBs, animal waste, fertilizers, pesticides
LAND: radioactive waste, plastic, toxic ash, paper, metal, yard waste

4. Have each team pick a captain. Then have the teams hang their drawings where everyone can see them.

Playing the Game

Tell the kids that the object of the game is to get rid of all 12 pollutants from their scene. To do that, they'll have to correctly answer pollution questions. To play, have a person from the first team draw one of the numbered slips of paper from the sack. Then read the corresponding question listed under "Pollution Puzzlers" below. Only the team captain can answer, but he or she should confer with the rest of the team before giving an answer.

If team members answer the question correctly, they get to remove one or more of the pollutants from their scene. (Some of the questions indicate that a team can remove two pollutants.) If they answer incorrectly, the numbered slip of paper goes back in the sack. After one team has a turn, it's time for another team to pick a question and answer it. If team members pick a slip with an X, they have to put one pollutant back on their drawing (if they've lost one) and they don't get to answer a question. But if they pick a slip with an O, they get to take a pollutant off their drawing and then pick another question. You can play until one team has removed all 12 pollutants, or you can set a time limit and declare a winner when the time is up.

What Do You Think?

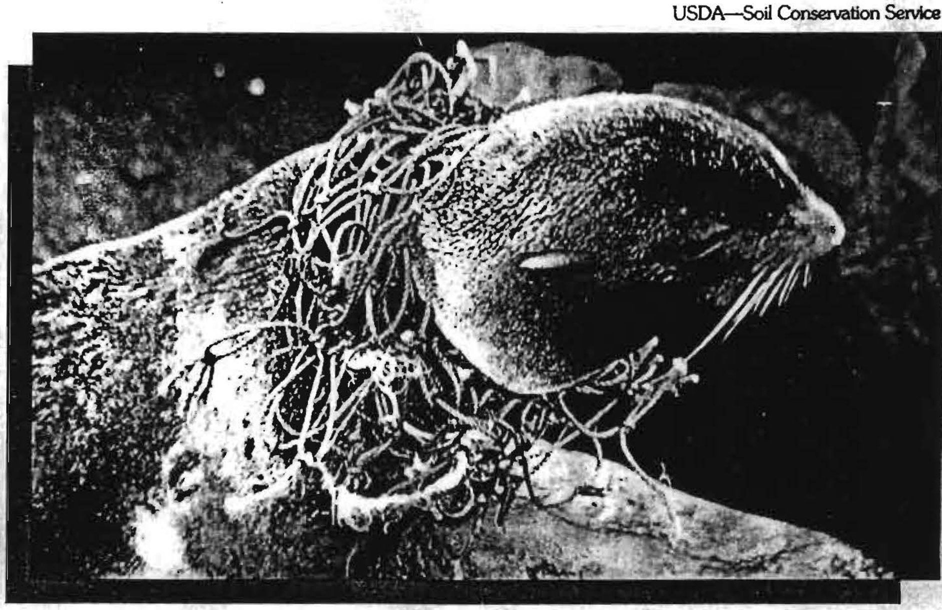
1. What is pollution? List five examples of pollution.
2. List some of the causes of pollution.
3. How do you contribute to pollution? Name three ways.
4. What are three things you could do to help reduce pollution?
5. Give some examples of how pollution affects living things and the environment.
6. Can pollution in one country harm people in another country? Explain your answer.
7. Do you think the United States creates more pollution than other countries? Explain your answer.

Pollution Puzzlers

1. Which of the following is an example of pollution? Give all correct answers. (all)
a. litter in a stream
b. noise from a nearby airport
c. cigarette smoke in a restaurant
d. a billboard
e. fishing line tangled around a log
2. Name three major pollution events that have occurred in the last decade. (*Exxon Valdez* oil spill; Chernobyl nuclear power plant explosion; *Mobro* garbage barge, and so on)
3. How does the world's increasing human population contribute to pollution problems? (more people means more hazardous materials; more garbage; more energy use, which contributes to pollution; and so on)
4. Give an example of noise pollution and explain how it can hurt people and other living things. (construction noise, noise from jets and motor vehicles, noise from stereos, and so on; can damage people's hearing, can disturb wildlife breeding and feeding activities)
5. Which pesticide caused a decrease in bald eagle populations following World War II? (DDT)
6. What is the connection between plastic foam and the ozone layer? (Some foam is made with CFCs, which deplete the ozone layer.)
7. True or false: Plants can help absorb indoor air pollution. (true)
8. What are fossil fuels? (coal, oil, and other fuels that formed millions of years ago from the remains of ancient plants and animals)
9. True or false: Air pollution inside buildings can sometimes be worse than air pollution outside. (true)
10. Name three things that contribute to indoor air pollution. (cigarette smoke; emissions from copy machines, art supplies, new carpeting and furniture; and so on)
11. Name two possible consequences of global climate change. (sea level rise, droughts, cooling or warming in some areas, extinction of some species of plants and animals)
12. What air pollutant is the main contributor to the greenhouse effect? (carbon dioxide)
13. [worth two pollutants] Name two ways that low-level ozone can affect people or the environment. (makes people's eyes and throats burn, damages crops and forests, makes rubber and other materials deteriorate faster than they normally would)
14. How does acid rain form? (pollutants released from power plants and motor vehicles combine with water droplets in the atmosphere and fall to earth as acid rain, fog, or snow)
15. Why is it important to protect the ozone layer? (to keep the amount of harmful ultraviolet radiation that reaches the earth from increasing, which would increase occurrences of skin cancer and affect plant growth)
16. How can deforestation contribute to global climate change? (the burning of forests releases more carbon dioxide into the air and also removes trees and other vegetation that would otherwise absorb carbon dioxide)
17. [worth two pollutants] Name three products that contain CFCs. (some aerosols, computer parts, coolants for refrigerators and air conditioners, many kinds of foam products)
18. How can cutting down on energy use help reduce air pollution? (reduced demand for electricity results in less coal or oil being burned in power plants, which results in less air pollution)
19. True or false: Air pollution is something you can always either see or smell. (false)
20. What is groundwater? (underground water that fills the spaces between soil particles and rocks)
21. What are some of the ways groundwater gets polluted? (leaking landfills, leaking hazardous waste sites, pesticides and other chemicals seeping through the soil, and so on)

22. The area of land that rain and snowmelt drain off of is called a ______. (watershed)
23. Toxic chemicals gushing out of a pipe into a river is an example of what kind of pollution: nonpoint or point pollution? (point pollution)
24. Pesticides, oil, and fertilizers washing into rivers from roads, fields, and farms is an example of what kind of pollution: nonpoint or point pollution? (nonpoint pollution)
25. More ocean oil pollution comes from: (b)
a. large oil tanker spills
b. routine cleaning of empty oil tankers
26. [worth two pollutants] Name four substances that can contaminate groundwater. (pesticides, road salt, motor oil, fertilizers, animal waste, gasolihe, battery acids, and so on)
27. True or false: Wetlands can help purify water by absorbing harmful pollutants. (true)
28. Name two ways that plastic trash can harm wildlife. (when eaten, can block digestive system and cause starvation; can entangle or strangle birds and other animals)
29. What ingredient in laundry detergent can cause algae to grow much faster than normal? (phosphate)
30. What is sludge? (solid waste from sewage treatment plants)
31. What annually uses the most water in homes: dishwashers, toilets, or bathtubs? (toilets)
32. Name three things that can contaminate lakes, streams, rivers, and oceans. (pesticides, fertilizers, trash, human sewage, agricultural waste, industrial chemicals, acid rain, dirt and other sediment, oil and gasoline, and so on)
33. Name a product in your house or garage that can cause water pollution. (cleaners, silver polish, pesticides, paint thinner, motor oil, laundry detergent, and so on)
34. Name four garbage items that can be recycled. (glass bottles, plastic soda bottles, branches and leaves, motor oil, and so on)
35. What does a resource recovery plant do? (sorts trash and recovers the metals, paper, and other valuable materials, and then burns the remaining trash to produce energy)
36. Give three examples of hazardous waste. (pesticides, oil, paint thinner, acids, explosives, radioactive waste, and so on)
37. How do we currently dispose of more than 75 percent of our trash? (by dumping it in landfills)
38. What is *integrated waste managment?* (waste disposal system that makes use of recycling, source reduction, incineration, and landfilling)
39. Name several types of farm waste that contribute to pollution problems. (manure, crop residues, pesticides, fertilizers, and so on)
40. Define *biodegradable.* (having the ability to be broken down into simpler substances by bacteria and other organisms)
41. What are three ways that plastic contributes to global pollution problems? (made from oil, which if spilled during transport can pollute water; manufacturing process creates air pollution; plastic litter can strangle or entangle wildlife; adds to solid waste problem)
42. How does recycling save energy and resources? (eliminates need to extract and process more raw materials, which depletes natural resources and uses more energy)
43. [worth two pollutants] Name three ways cars contribute to air, land, and water pollution. (see page 8)
44. Name three ways people can reduce pollution caused by cars. (carpool, walk, bike, or use public transportation; recycle used motor oil; keep cars tuned up for better fuel efficiency; recycle air-conditioning coolant; and so on)
45. How can dirt and other sediment harm aquatic animals and plants when it washes into lakes, rivers, and streams? (smothers bottom-dwelling organisms; clogs fish gills; keeps sunlight from reaching aquatic plants; decreases visibility, making it harder for some animals to find food; and so on)
46. Explain why biodegradable materials don't break down in landfills. (lack of water and oxygen prevents bacteria and other organisms from breaking down landfill materials)
47. What are three ways that communities can help reduce pollution? (set up recycling programs, provide public transportation, sponsor hazardous waste pickup days, and so on)
48. [worth two pollutants] Name a national law that was passed to help reduce pollution. (see page 83)
49. [worth two pollutants] Give an example of a technology that causes pollution problems *and* an example of a technology that cuts down on pollution problems. (causes problems—cars, power plants, plastic, and so on; solves problems—smokestack scrubbers, catalytic converters, biodegradable plastics, and so on)
50. Name two energy sources that create minimal pollution. (solar, wind, and geothermal power)
51. Name three ways that consumers can help cut pollution. (buy products in recycled and recyclable packaging; buy in bulk; don't buy overpackaged goods, toxic products, and disposable items; write to companies; and so on)
52. Name two ways that acid rain affects the environment. (speeds up the erosion of buildings and statues; can kill some fish and other aquatic animals and can harm their eggs and young; may make trees more susceptible to disease, cold, and insect attack)

USDA—Soil Conservation Service



Forest Ecology

Objectives:
- Understand the basic needs of living things
- Use equipment and the human senses to collect information
- Take measurements and conduct counts
- Graph information gathered
- Distinguish between a system and a subsystem
- Observe sequences and determine the next outcome
- Identify how plants and animals have adapted to their environments

What to Teach	Teaching Suggestions
Grow a tree.	- See "Grow a Sprout!" for instructions.
Discuss the process of growth from a seed to a seedling	- Background information: "Growing up a Tree." - Define the terms embryo, germination, seed coat, seedling, photosynthesis, etc.
Discuss the needs of growing seedlings.	- Experiment with different growing conditions to see how the seedlings, started above, are affected when one of their "needs" is taken away
How have seedlings adapted to better their chances of survival?	- Discuss ways in which seeds can move from place to place (ie. wind, water, animals). This movement betters their chances at finding suitable habitat in which to grow. - Have students do the activity titled "Seed Need" to illustrate one way in which seeds are transported.
Discuss what makes up a forest community	- See "The Forest Community" for background information. - Discuss the different forest layers and who and what can be found at each layer. - See "Forest Community" for an illustration of the different communities within the forest community.

What to Teach	Teaching Suggestions
Trees are a big part of the forest community. Most forest animals use these trees at one time or another. Discuss the ways in which various animals use trees.	- See the activity titled "Under Cover"
A lot of the forest community can be found on the forest floor. This is the area where all of the dead trees and fallen leaves go to decay. Discuss with students the importance of decaying logs and leaves to the forest community.	- Define decomposition - Discuss why a rotten log is important in a forest. - See "A Rottin' Place to Live" for information and an activity (any rotting log can be used for this activity, including logs in backyard or schoolyard woodpiles). - Have students do the activity "Life on a Rotting Log"
Visit Sharon Woods Metro Park.	**- This is an introduction to the ecology of the wet woods at Sharon Woods. The naturalist will lead students on a discussion of the habitats of the forest and on the processes of succession and decomposition. Students will also be provided a chance to explore the forest floor along the trail, take measurements, and record observations on what was found.**
Forest plot studies.	- See the activities titled "A Study of the Forest Floor" and "Micro-Plot Studies." These forest plot studies can either be done at the park in conjunction with the visit (if time permits) or they can be done around the school.
Compile information and discuss what was found.	- Students could write short reports on their observations recorded in the microplot study areas. - Have students construct graphs depicting the numbers of plants found versus animals found, the number of sow bugs and/or seeds, and etc.

What to Teach	Teaching Suggestions
Discuss forest succession referring back to what was seen at Sharon Woods (ie. fields, brushy areas, forests)	- Are all forests the same age? - What would happen if we would let our yard grow up? What would it eventually turn into? - Define succession - the orderly replacement of one plant community by another. - See "Forest Succession" for information.
Student activity.	- Background information: "Plant Succession" - Have students do "From Field to Forest"
Demonstration.	- Help students put together a "Forest in a Jar" to observe first-hand the process of succession.

Grow a Sprout!

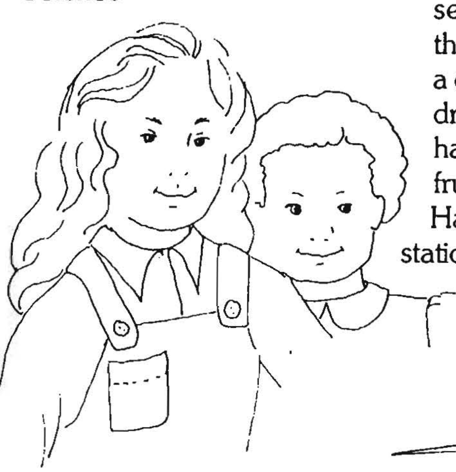
Plant tree seeds and observe how they grow.

Objectives:
Describe a tree seedling's roots and stem. Discuss the things tree seeds and seedlings need in order to grow.

Ages:
Primary

Materials:
- ***several citrus fruits***
- ***styrofoam cups (one for each person)***
- ***sand or half-and-half mixture of soil and perlite***
- ***several small spoons***
- ***ballpoint pen***
- ***toothpicks (optional)***
- ***avocado seeds (optional)***
- ***glass jars (optional)***
- **Billy B. Sings About *Trees, an album by Bill Brennan (see page 75 for details on how to order)***

Subject:
Science

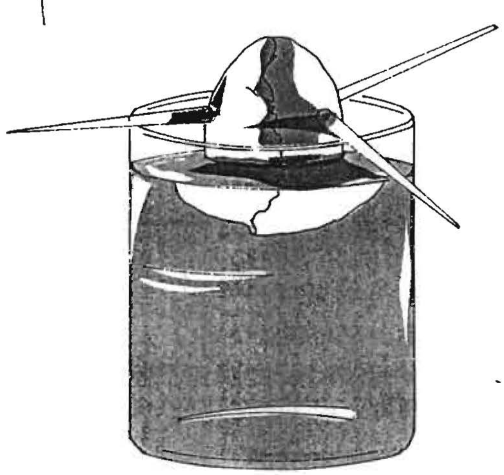


To help your kids get an idea of how trees sprout and what they need to stay alive, have them grow their own trees from seeds. Grapefruits, lemons, limes, oranges, and other citrus trees are some of the easiest trees to grow indoors—and of these, grapefruit trees are the fastest growers.

To get started, bring in (or have the kids bring in) several grapefruits or other citrus fruits. (Most grapefruits sold in grocery stores are "seedless," but these usually have at least a few seeds. Use only the largest seeds.) Set up two or three "planting stations" around the room, each with the following materials:

- styrofoam cups with several holes punched in the bottoms
- soil mixture or sand (To avoid microorganisms that could damage the seeds or young plants, get soil or sand from a store instead of digging it up.)
- small spoons for filling cups with soil mixture
- fruit seeds from a grapefruit or other citrus fruit (To avoid damaging the seeds, peel the fruit and break apart the sections instead of cutting through them with a knife. Also, put the seeds in a container of water to keep them from drying out.) If possible, use seeds that have already started to sprout inside the fruit.

Have the kids go up to the planting stations in groups of two or three. Each person can plant his or her own seed in one of the cups by filling the cup most of the way with the soil mixture or sand, laying a seed on top, and then covering it with another ½ inch (1.25 cm) of soil or sand. (Tell the kids not to pack the soil down.) Have the kids write their names on their cups with a ballpoint pen.

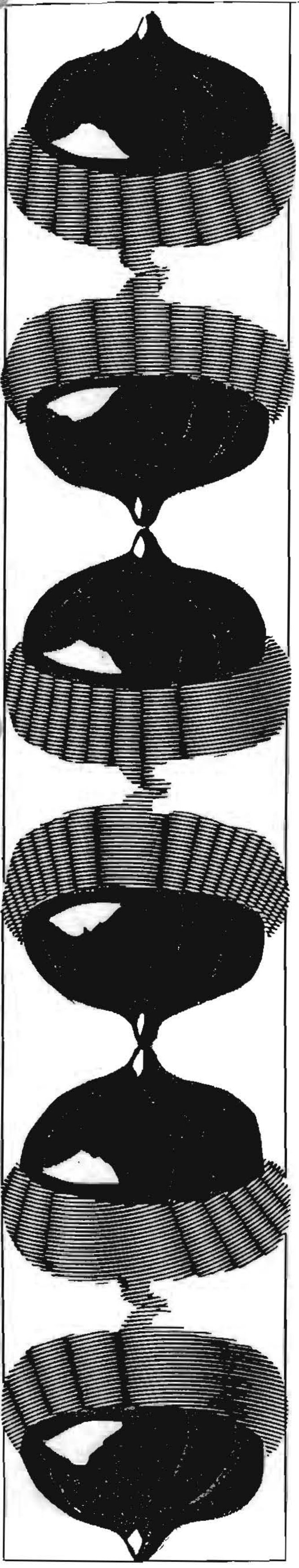


When everyone's finished planting, put the cups in a very warm (but not too sunny) spot. Add enough water to the soil to make it moist but not soaking wet, and make sure the soil never dries out completely. The seeds should sprout within a few weeks. (If some seeds don't sprout, have the kids replace them with fresh seeds. You can get a grapefruit seed to sprout within three to four days or so by gently peeling off the seed's covering with a razor blade before you plant it. Be sure to start peeling from the seed's rounded end and to be especially careful when you reach the seed's pointed end, where the embryo is.) As the seeds grow, discuss with the kids how seeds develop and the things seedlings need in order to grow. (See the background information on pages 25–27.)

Another good "grow-your-own" tree is the avocado. By suspending an avocado seed in water, your kids will be able to see how a seedling's stem *and* roots grow. Just peel the brown papery covering away from the seed, poke three toothpicks into it at equal distances from one another, and let the seed rest in a glass of lukewarm water with its *large end* submerged. Make sure the water doesn't evaporate to the point where it no longer covers the bottom of the seed, and replace the water with fresh lukewarm water once a week. Avocados take about three weeks to sprout. When the avocado's stem and roots are several inches long, it needs to be planted in a pot that's about one inch (2.5 cm) wider than the avocado.

To reinforce the things the kids are seeing as they watch their seedlings grow, play Bill Brennan's "Yippee, Hooray (I Am a Sprout)," a song included on his *Billy B. Sings About Trees* album.

GROWING UP A TREE



It's late spring and the trees are loaded with pollen. Like a thick dusting of talcum powder, it covers the male cones of gymnosperms and the male flower parts of angiosperms. The pollen is ready to be swept up by the wind or carried along by bees, bats, birds, and other forest creatures.

Pollen grains are microscopic bits of life—male cells that must reach their female counterparts to do the job they were "made" for. In the case of cone-bearing trees, such as pines and firs, the pollen must land on a female cone and slide down a scale to the immature seeds (ovules) inside. With flowering trees, such as beeches, maples, and magnolias, the pollen must land on the tip of a *pistil* (female flower part containing the ovules) inside one of the flowers. For both types of trees the mission is the same—to fertilize an egg and form a mature tree seed.

FROM SEED TO SEEDLING

Starting Out a Seed: Most trees begin as seeds. And every tree, sooner or later, begins the business of producing seeds of its own.

A seed is really a tiny blueprint of the tree to come. The tiny embryo inside is complete with parts that will eventually develop into a shoot, roots, and leaves. Also included is a storehouse of energy—a supply of food in the form of starch, sugar, and fat. This food nourishes the living embryo while the seed lies dormant. After the seed germinates, or sprouts, the food supplies the embryo with energy for growth until leaves are formed and photosynthesis can begin.

Move It or Lose It: When it comes to reproduction, trees—like all plants—are big-time gamblers. Each season's production of seeds is a game of chance in which the odds of any one becoming a mature tree are about "one in a million."

A seed that ends up at the base of the parent tree may sprout there and become a seedling. With luck the seedling will become a *sapling,* or young tree. But unless the parent tree dies, is knocked down in a storm, or is cut down, the sapling has little chance of becoming a mature tree. There's usually no way it can successfully compete with the parent for enough light.

Their chances of surviving are improved if seeds can be spread to other areas, or *dispersed.* So the seeds of most trees are made to travel.

"Oh, Give Me a Home . . .": Travel, of course, has its own hazards. Seeds have many amazing ways of getting around, but they cannot control exactly *where* they go. A floating coconut, which needs to land on a sandy shore to sprout, may drift for years at sea. A maple seed sailing on the wind can end up in someone's backyard and, although it succeeds in sprouting, may fall prey to a lawn mower. A cedar seed that needs lots of sunlight may land in the shade of a deep forest. And a cottonwood tuft that needs a moist stream bank may end up on a dry, dusty roadside.

To sprout and begin growing, a seed must—by luck—fall in a place with the right amount of light, right temperature range, right amount of moisture, and sufficient and suitable soil.

Ready, Set, Grow!: If a healthy seed lands in just the right spot, it begins to grow. (Some species need to lie dormant through freezing temperatures before they can sprout; others can sprout right away.) First the seed begins to absorb water from the soil, causing the embryo inside to grow larger. Next a tiny root tip pokes its way through the seed's hard outer covering (called the *seed coat*) and digs into the soil.

(continued next page)

Soon, tiny root hairs begin to sprout along the root. These tiny strands push between particles of soil, absorbing water and minerals. The mineral-rich root sap flows up to the rest of the tiny seedling.

With a steady supply of water and minerals, the seedling next sends out a shoot. Cells inside the shoot begin to grow and multiply, sending the future tree trunk up through the soil. (Special chemicals in the shoot, called growth hormones, cause the shoot to grow *up,* against gravity.) Soon—usually within a few days—the new shoot breaks through the surface of the soil.

FROM SEEDLING TO ADULT

Laying On the Layers: Once a seedling breaks ground, it's on its way to becoming a young tree. Leaves grow and immediately begin the job of making food. During its first growing season, the young tree's phloem and xylem cells transport food, water, and minerals to all parts of the tiny seedling (see page 6 for more about the cambium, phloem, and xylem). As more woody xylem cells form, the stem becomes thicker and stronger.

It's Up to You, Bud: As a tree grows, it not only develops a thicker trunk—it also grows taller. Trees grow taller only at the tip of the trunk and at the tips of the branches. They do this by forming *terminal buds.* Each bud contains a tiny shoot that, on most trees, is wrapped in protective *bud scales.* The scales form a tough, weatherproof "suit of armor." When the bud sprouts, a new green shoot starts to grow and eventually becomes a new branch. (In climates with a cool or cold season, terminal buds form during the growing season and then lie dormant until spring.) Besides having buds on the tips of their branches, most trees also have buds that form on the *sides* of their branches.

Shutting Down for Winter: Tree growth slows as cold weather approaches, and the buds that formed during the growing season eventually become dormant. In deciduous trees, chlorophyll in the leaves gradually breaks down and photosynthesis eventually stops. Because water is not as available to trees during cold weather as it is during the growing season (it freezes and is not as easily absorbed by the roots), shutting down photosynthesis is one way deciduous trees can survive the winter. (Plants need water in order for photosynthesis to take place.) And since deciduous trees don't photosynthesize during winter, they no longer need their leaves. So deciduous trees simply get rid of their leaves as the weather turns colder. (In many tropical areas and other areas that have a wet and a dry season instead of spring, summer, winter, and fall, deciduous trees drop their leaves as the dry season approaches.)

Many evergreens survive winter or the dry season with their leaves still hanging on because they have special adaptations to compensate for scarce water supplies. For example, many evergreen leaves are covered with a thick, waxy coating that helps hold water in and prevents evaporation. Also, the leaves of some evergreens contain a kind of natural antifreeze that helps prevent injury to water-filled cells.

Making More Trees: Most trees reproduce sexually. That means male cells (formed in the pollen) unite with eggs (formed in the cones or blossoms, depending on the type of tree) to make seeds. But many trees can also reproduce *vegetatively,* which means they can grow from a part of the living tree. Some trees grow from *suckers,* which are shoots that sprout from the roots. Other trees can grow when twigs fall to the ground and eventually form roots. Many trees can also sprout from stumps.

GROWING UP A FOREST

Trees grow together in communities called *forests*. The types of trees that grow in a particular forest community depend on the climate in the area and the type of soil that is found there. Although there are thousands of species of trees in the world, scientists have divided the world's forests into four major groups:

Boreal Forests: These form a broad band across northern Canada, Europe, and Asia. Boreal forests are made up mostly of firs, spruces, and other needle-leaved trees that are adapted to cold winters and a short growing season. (These types of forests are also found in many mountainous areas where the climate is similar to that of the far north.)

Mixed Forests: South of the boreal forests are areas of mixed forests, made up of conifers and deciduous trees. Mixed forests grow across much of North America, Europe, and Asia, in areas where the climate is milder than it is in boreal areas.

Deciduous Forests: In many temperate areas broad-leaved deciduous trees such as beech, maple, oak, and hickory form large tracts of deciduous forests. (Deciduous forests often contain some pines, hollies, and other evergreens, but these usually aren't the dominant trees.) In the past, much of North America and parts of Europe were covered with unbroken tracts of deciduous forests.

Tropical Forests: These forests, which grow in parts of Central and South America, Africa, Asia, and Australia, form a broad band around the equator. Because they grow in areas where there are warm temperatures year round, long hours of daylight, and lots of rain, these forests are lush and productive. Most of the trees that grow in these forests are broad-leaved evergreens. (See pages 50 and 52 for more about tropical forests.)

Bruce Norfleet

SEED NEED

Objectives

Students will be able to: 1) explain how seeds are carried by animals; and 2) evaluate the importance of wildlife in contributing to ecological systems, based on this example of seed dispersal.

Method

Students gather seeds by going outside and wearing socks over their shoes.

Background

Wildlife contributes to the diversity and balance of ecological systems. One compelling example is in the process of seed dispersal. Many seeds are carried by animals—whether in the coats of fur-bearing animals, or in seeds carried and dropped by some birds.

The major purpose of this activity is for students to understand one example of wildlife as contributors to healthy ecological systems.

Materials

one large fuzzy sock per student, or masking tape segment per student (Optional: one shoe box filled with planting medium per student, cookie sheets or trays in which to place shoe boxes used as planters)

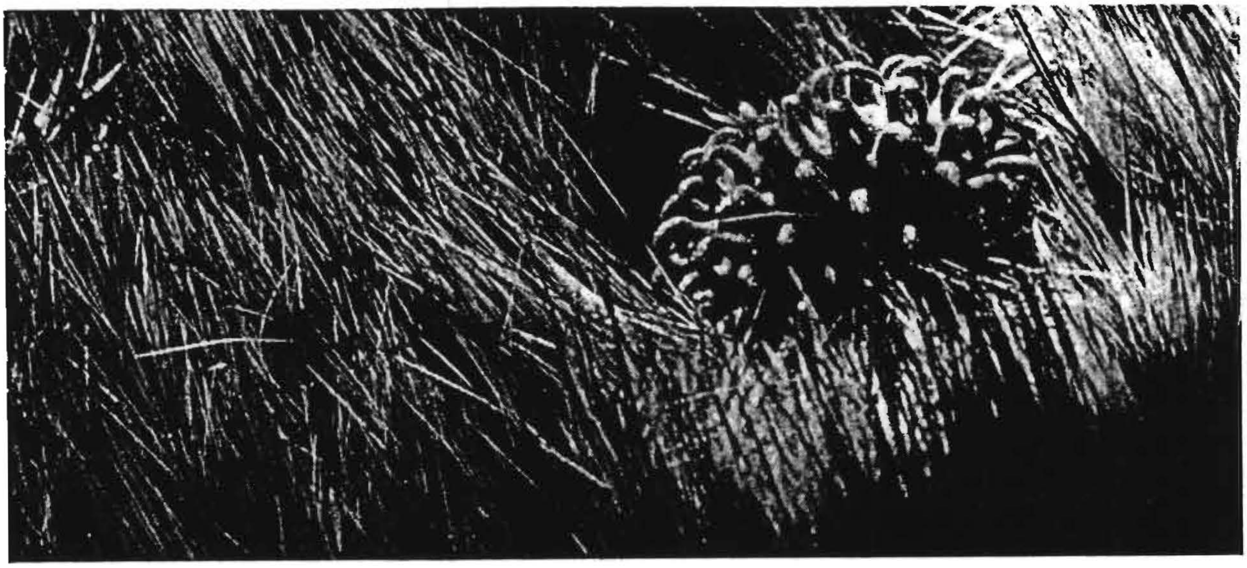
Procedure

1. Ask each student to bring a large, old, fuzzy sock from home—or try to find an inexpensive or free source to obtain a sock for each student. Old socks with holes in them are fine for this activity. Ask each student to put on a sock over one shoe. Wearing the socks over the shoes, go on a walk through a grassy area or field—particularly one that is abundant in seed-bearing plants. (Masking tape over the foot or around the leg sometimes has more sticking powerl)

Option for older students: Different students walk in different locations. Contrast seeds found in each location. Create an "environmental map." What ecosystem differences exist in the neighborhood, city, etc.?

2. After walking through the area, look carefully at the socks. What has happened? Discuss briefly

Age: Grades 5—6 (and younger)
Subjects: Science, Math (Social Studies for older students with mapping)
Skills: analysis, classification, comparing similarities and differences, description, kinesthetic concept development, listing, observation, writing
Duration: 20—40 minutes or longer for gathering and analyzing data; minimal ongoing time in caring for planted seeds
Group Size: any
Setting: outdoors and indoors
Conceptual Framework Reference: II.B., II.B.1., III.B., III.B.1.
Key Vocabulary: ecosystem, dispersal, seeds, diversity



the seeds and other things that are attached to the socks. If the distance is not too great back to the classroom, the students should keep their socks on their feet until they return. If the distance is too great—they may lose too many of their seeds along the way! NOTE: Wildlife drops seeds too—that's one way they get dispersed!

3. The students should carefully remove their socks. They've gathered their "data"—seeds and other things attached to their socks. Removing the seeds and other particles from the socks—they should examine what they've brought back. Talk with the students about the major kinds of things they seem to have—like seeds, grass, small bits of twigs. Next, discuss the seeds in more detail, talking about the different kinds of seeds they have found: round, skinny, big, small, etc.

4. Each student should record—with words and small drawings—the kinds of things on the sock. Tally the **number** of each kind of thing on a sock as well.

5. Ask the students how different animals' fur might be similar to their socks. Has anyone ever brushed seeds, stickers, and things out of a dog's or cat's fur? Talk with the students about how, so often in nature, seeds are carried by animals almost like the way they carried seeds and things on their socks. Seeds may stick to an animal's fur in one location, and fall off in another. Discuss why such a process is an important one. Evaluate the consequences. How does wildlife contribute to environmental diversity.

6. OPTIONAL: Each student can plant his or her seeds in one of the shoe boxes filled with planting medium (soil or a commercial mix). Be sure the students put their names on their boxes. Water and care for the shoe-box gardens regularly—and see what grows! NOTE: Many wild plant seeds require freezing before they will germinate. If there is a question, put some seeds in ice cube trays and freeze them for several days. **Then** plant them.

Extensions

1. As the seeds in the boxes begin to sprout, measure the plants that grow. Take measurements every fifth day, and plot these measurements on a graph. Primary students can use strips of paper for measurement and use those strips to make an individual bar graph. Intermediate students can measure their plants with a metric ruler and plot their measurements on a line graph.

2. Students can try similar experiments at home, using seeds they find on their own or a neighborhood pet. If they actually get the plants to grow, they can try to match the plants they grow at home from the "pet-carried" seeds to the plants growing outside. Then they can try to figure out how far the seeds might have traveled on the animal!

Evaluation

Draw three different seeds that could be transported on the fur of an animal. Draw an arrow to show the part of the seed that makes this possible.

How are fur-bearing animals important to the types of plants that produce these seeds?

The Forest Community

Perched on a tree limb more than 100 feet (30 m) above the forest floor, Donald Perry found himself surrounded by a world of colorful orchids, exotic "air plants," and strange animals rarely seen by human eyes. There were unusual lizards that jumped from limb to limb, brilliantly colored parrots that somehow blended right in with the treetop foliage, and slow-moving sloths whose fur had turned green with the algae that lived on it.

Perry, a tropical biologist, was researching the upper reaches of a Costa Rican rain forest. Using a unique system of ropes and pulleys, he moved among the treetops and hoisted himself up and down between high branches and the forest floor. And as he traveled in his makeshift "elevator," he saw that the plants and animals that lived in the leafy branches were very different from the ones that lived on the forest floor. In fact, he observed many "layers of life"—each with plants and animals that were specially adapted to living at certain heights in the forest.

The Costa Rican forest Perry observed is just one example of a forest community. Like all forest communities, it's made up of certain species of trees, other plants, and animals that are specially suited to living in it. And as in other forest communities, hundreds of plant and animal interactions occur there every day.

FORESTS FROM THE TOP DOWN

In one sense, a forest—whether it's a stretch of tropical rain forest in Costa Rica or a wooded hillside in Vermont—is several communities in one. That's because all forests are made up of layers of plants. Below is a look at some of the layers that might be found in a forest, starting with the forest's "roof" and working down. (The number and kinds of layers vary from forest to forest, depending on the types of trees and other plants that grow there.)

On Top of It All: Made up of the branches and leaves of the tallest trees, a forest's *canopy layer* can be 100 feet (30 m) or more above the ground. A lot of sunlight hits the canopy, making this layer a huge food-making factory where most of the forest's photosynthesis takes place.

Beneath the Big Ones: Growing under the canopy trees may be shorter trees that make up the *subcanopy layer.* Some of these trees are offspring of the canopy trees, and they may eventually become part of the canopy too. Other understory trees are smaller, altogether different species that are adapted to growing in shade.

Low-down Plants: Of course, trees aren't the only plants that grow in a forest. Beneath a forest's subcanopy, for example, may grow a *shrub layer.* Shrubs are usually smaller than trees and have many woody stems, instead of the one main stem that trees have.

At the Bottom: Ferns, grasses, wildflowers, seedling trees, and other close-to-the-ground plants are all part of a forest's *herb layer.* And hollow logs, fallen branches and leaves, lichens, and mosses are all part of the *forest floor.*

Note: Some scientists use the word *understory* to refer to the layers in a forest that grow beneath the canopy. Many biologists also include a *tree trunk layer* in the list of forest layers. That's because many birds and other creatures nest in or feed on the trunk. Also, many forest insects and other small animals spend their entire lives under the bark of a tree's trunk.

HOW MANY LAYERS?

Climate, forestry practices, soil conditions, the age of the forest, and other factors can influence the number of layers that develop in a forest. (See pages 48–50 for more about forestry.) For example, a planted stand of white pines may have only the forest floor, tree trunk, and canopy layers. A tropical rain forest, on the other hand, might have all of the layers we talked about before—plus "extras " such as an *emergent layer* of very tall trees that tower above even the canopy.

WHERE THE ANIMALS ARE

You'd never find a red squirrel building its nest on the forest floor. And even though wild turkeys can fly, you'd be unlikely to see one flying from branch to branch up in the forest canopy, searching for food. That's because most forest species usually nest, feed, and carry out their other activities in one or two of a forest's layers. For example, red squirrels are basically canopy animals, and wild turkeys spend most of their time on the forest floor. Each finds what it needs to survive in particular layers of the forest.

Even songbirds and other animals that can quickly and easily get from place to place tend to be "tied" to certain forest layers. For example, if you studied the warblers in a typical deciduous forest community in Maryland, you might find cerulean warblers living in the canopy, black-and-white warblers living on the tree trunks, Kentucky warblers living in the understory, and ovenbirds (also a type of warbler) spending most of their time on the forest floor. All of these tiny songbirds are closely related—but each is adapted to living in a different forest layer. In this way, none of the warblers competes with the others for the same food or nesting sites. (See the activity on page 36 for information on how some canopy animals are adapted to their habitats.)

THE FOREST MACHINE

You can think of a forest community as a kind of self-sufficient, living machine—constantly recycling energy and nutrients through its system. Here are the "parts" that keep things running:

Producers: The producers are the trees and other green plants that make the food needed to fuel the forest machine. (See page 7 for more about how plants make their food using energy from the sun.)

Consumers: The consumers are the animals in a forest community that either eat green plants directly or get the energy from green plants indirectly by eating animals that feed on green plants.

Decomposers: The decomposers are the fungi, bacteria, earthworms, and other organisms that break down dead material in the forest community. They recycle the forest machine's waste products, turning dead plants and animals into usable nutrients (nitrogen, phosphorus, and others) that can be absorbed by the roots of trees and other producers. (See page 41 for more about decomposition.)

Over and over again, energy and nutrients are recycled through the forest community, as they are in all communities—from producer to consumer to decomposer and back to producer. And the forest machine keeps on running year after year.

FOREST COMMUNITY

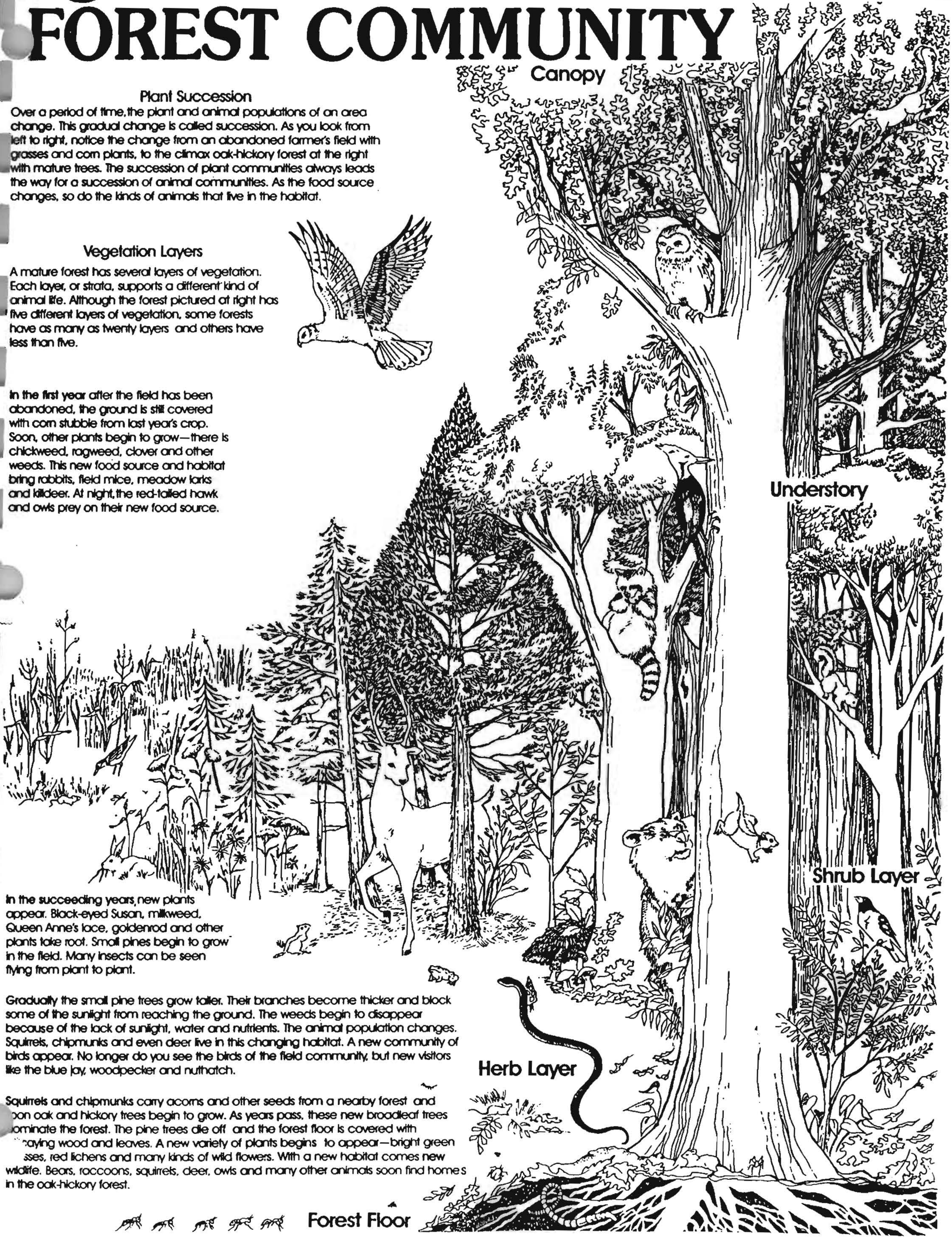
Plant Succession

Over a period of time, the plant and animal populations of an area change. This gradual change is called succession. As you look from left to right, notice the change from an abandoned farmer's field with grasses and corn plants, to the climax oak-hickory forest at the right with mature trees. The succession of plant communities always leads the way for a succession of animal communities. As the food source changes, so do the kinds of animals that live in the habitat.

Vegetation Layers

A mature forest has several layers of vegetation. Each layer, or strata, supports a different kind of animal life. Although the forest pictured at right has five different layers of vegetation, some forests have as many as twenty layers and others have less than five.

In the first year after the field has been abandoned, the ground is still covered with corn stubble from last year's crop. Soon, other plants begin to grow—there is chickweed, ragweed, clover and other weeds. This new food source and habitat bring rabbits, field mice, meadow larks and killdeer. At night, the red-tailed hawk and owls prey on their new food source.



In the succeeding years, new plants appear. Black-eyed Susan, milkweed, Queen Anne's lace, goldenrod and other plants take root. Small pines begin to grow in the field. Many insects can be seen flying from plant to plant.

Gradually the small pine trees grow taller. Their branches become thicker and block some of the sunlight from reaching the ground. The weeds begin to disappear because of the lack of sunlight, water and nutrients. The animal population changes. Squirrels, chipmunks and even deer live in this changing habitat. A new community of birds appear. No longer do you see the birds of the field community, but new visitors like the blue jay, woodpecker and nuthatch.

Squirrels and chipmunks carry acorns and other seeds from a nearby forest and soon oak and hickory trees begin to grow. As years pass, these new broadleaf trees dominate the forest. The pine trees die off and the forest floor is covered with decaying wood and leaves. A new variety of plants begins to appear—bright green grasses, red lichens and many kinds of wild flowers. With a new habitat comes new wildlife. Bears, raccoons, squirrels, deer, owls and many other animals soon find homes in the oak-hickory forest.

Under Cover!

Take a look at the animals that use a tree by making a "peek-a-tree."

Objective:
Describe three ways trees are important to wildlife.

Ages:
Primary and Intermediate

Materials:
- ***copies of pages 46 and 47***
- ***small, pointed scissors***
- ***crayons or markers***
- ***blank sheets of paper***
- ***pencils (optional)***
- ***tape***
- ***stapler***

Subject:
Science

Here's a fun way for kids to discover some of the many ways animals use trees. First pass out a copy of page 47 to each child and explain that all of the animals in the picture use trees or the areas around them for shelter, for food, or as a nesting site. Then tell them that they probably wouldn't find all of these animals on the same tree at the same time. That's because animals use trees for different things during different times of the year and they tend to spread themselves out among different trees so they'll have plenty of room.

As you discuss the animals in the picture you can use the information provided below. Afterward, pass out copies of page 46 and let each child make his or her own "peek-a-tree." *Note:* In the discussion below, the names of the animals that appear on pages 46 and 47 are in italics.

Hidden By The Leaves

A Place to Rest: Many birds use trees as resting spots. For example, the *barred owl* may rest in the branches of a tree during the day or may perch there at night to look and listen for mice and other prey.

Nesting High: A fork in a tree may be a perfect place for a *rose-breasted grosbeak* to build its nest. Many other birds and some other animals such as squirrels also build their nests in the branches of trees.

A Treetop Smorgasbord: The *gray squirrel* spends most of its time in the treetops and feeds on many different nuts, seeds, and fruits. A lot of other animals also feed in the treetops.

Blending In: Some animals are well camouflaged for their life in the trees. The *walkingstick* feeds on tree leaves during the day. Looking a lot like a small stick helps this insect hide from birds and other predators. Some other tree-dwelling insects resemble leaves, thorns, or bark.

Beneath The Bark

Growing Up Inside a Tree: Some animals spend most of their lives beneath the bark of trees. *Bark beetles* lay their eggs in wood underneath the bark. After the eggs hatch, the larvae form patterns in the wood as they eat their way through it.

Nesting Within: Many animals nest inside trees. Birds such as the *hairy woodpecker* chisel out their own nesting holes in trees. These cavities may be used by many other forest creatures after the woodpeckers have abandoned them. *Honey bees*, flying squirrels, and some birds may build their homes (hives or nests) in abandoned woodpecker nests or in other tree cavities.

Fruiting Fungi: Many types of fungi grow on trees. The threadlike *mycelium* of these fungi often grows beneath the bark, hidden from view. But when a fungus such as the *shelf fungus* produces its fruiting body, it's easy to spot.

Around The Roots

Feeding on the Roots: Many insects, mites, *millipedes*, and pill bugs spend part of their lives in the ground. The *cicada*, for example, spends its underground life as a nymph around the base of a tree, feeding on sap from the tree's roots. Some fungi form a "partnership" with the roots of trees. These fungi grow around the growing tips of the roots and feed on the tree's sap. The fungi aid the tree by absorbing nutrients from the soil and passing them into the tree.

Burrowing, Furrowing: *Earthworms*, moles, and many other creatures tunnel through the soil beneath a tree. As they churn up the soil they make it easier for a tree's roots to grow and absorb oxygen. Some animals such as *short-tailed shrews* and *chipmunks* dig tunnels beneath trees. And animals such as chipmunks and squirrels may store a cache of nuts in the ground near the base of a tree.

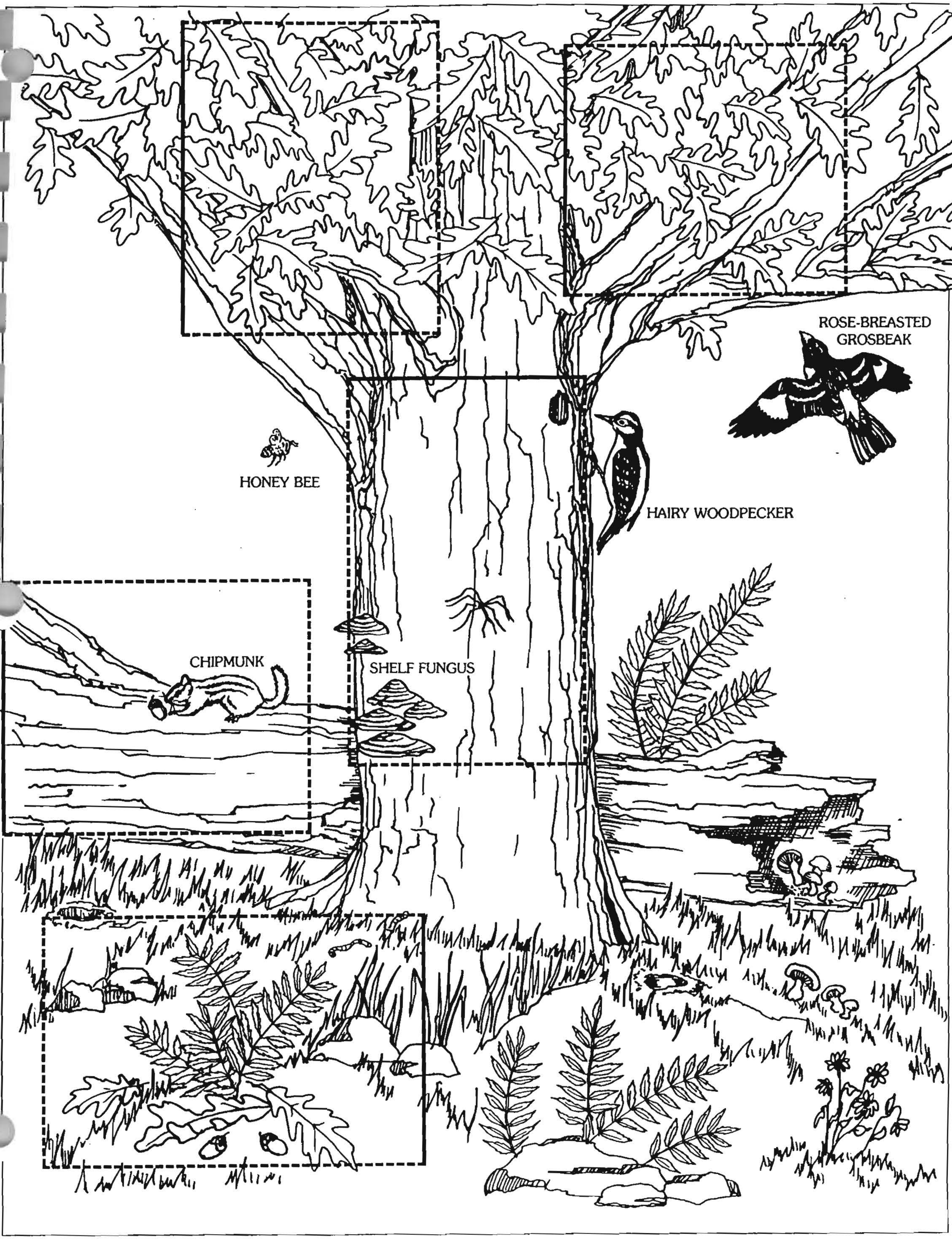
How To Make A "Peek-A-Tree"

1. Color sheets A and B.
2. Using pointed scissors, cut the rectangles on sheet A *on the dotted lines only*. Then fold the cut pieces back along the solid lines. (The rectangles should work like little doors.) If you're having trouble getting started, push the point of a sharp pencil through one of the corners of each rectangle. Then stick the point of the scissors through the hole and begin cutting.
3. Make a tab for each door by cutting out a small piece of paper 1 inch (2.5 cm) long by ½ inch (1.25 cm) wide. Tape half of the piece of paper

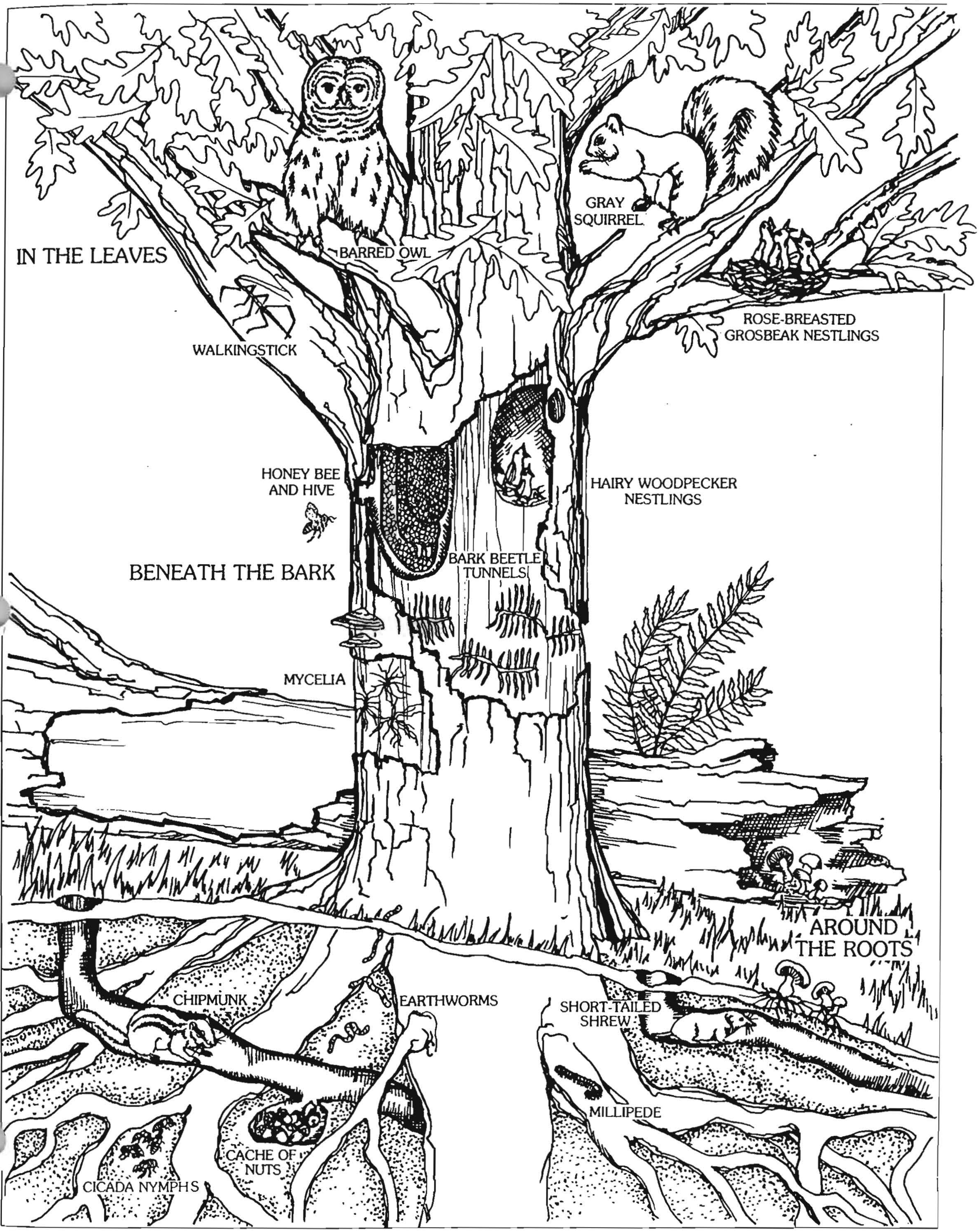
to the *back* of the door so that ½ inch (1.25 cm) hangs free and forms a tab. (Be sure to tape the piece of paper to the back of the door edge *opposite* the uncut side.) You can use the tabs to keep the doors closed by tucking them under the cut edges.

4. Put sheet A on top of sheet B and staple them together at the top and the bottom.
5. Then open the doors to see what is underneath the leaves and bark and around the roots!
6. Under the door with the chipmunk on it, draw a picture of a creature that might live in or on a rotting log.

UNDER COVER!—SHEET A



UNDER COVER!—SHEET B



A Rottin' Place to Live

Examine a decomposing log and then make a log mural.

Objectives:
Define decomposition.
Explain how dead trees are important to wildlife.

Ages:
Primary, Intermediate, and Advanced

Materials:
- ***paper sacks***
- ***leaves, twigs, and bark***
- ***newspaper***
- ***pencils and paper***
- ***clipboards or pieces of sturdy cardboard and rubber bands***
- ***magnifying glasses (one per person)***
- ***jars with lids or "bug" boxes***
- ***field guides***
- ***easel paper***
- ***yarn***
- ***construction paper***
- ***scissors***
- ***glue or tape***
- ***markers or crayons***

Subject:
Science

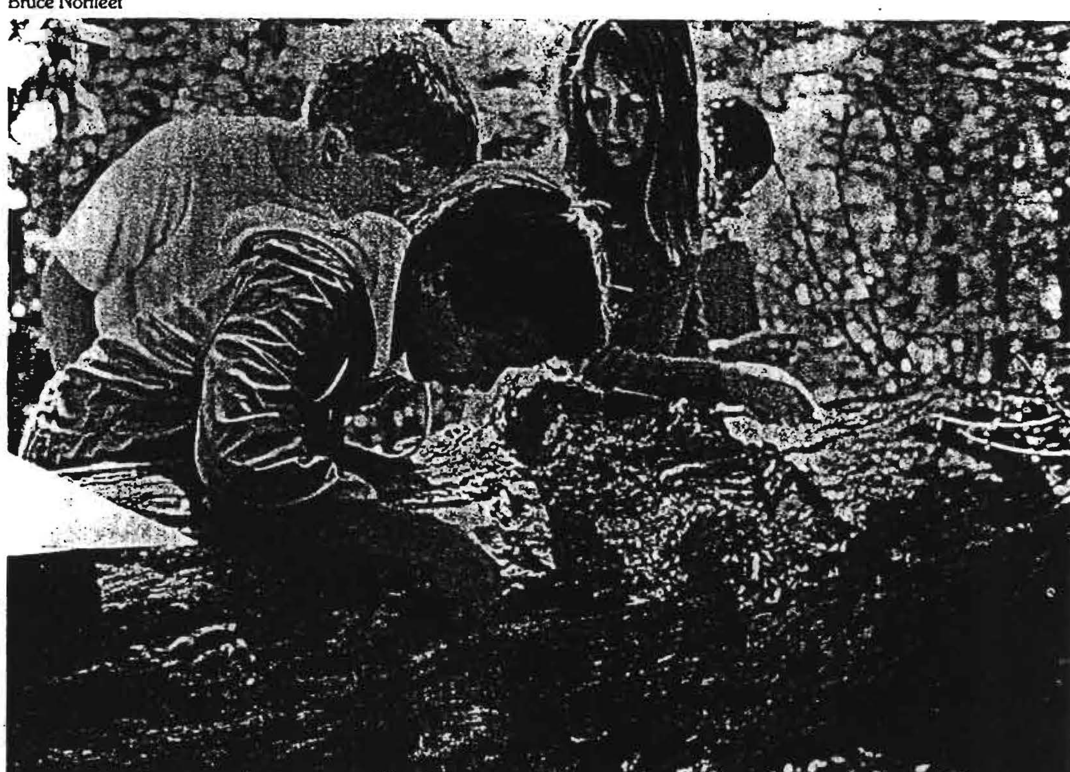
Have your kids take a close-up look at a dead log to learn about decomposition. Before you begin, collect some leaves, twigs, bark, and any other tree materials you can find. Put all of one kind of material into the same paper sack. (For example, put all of the leaves in one paper sack, all of the twigs in another, and so on.) Then spread out some newspaper in an area where all of the kids can gather around it.

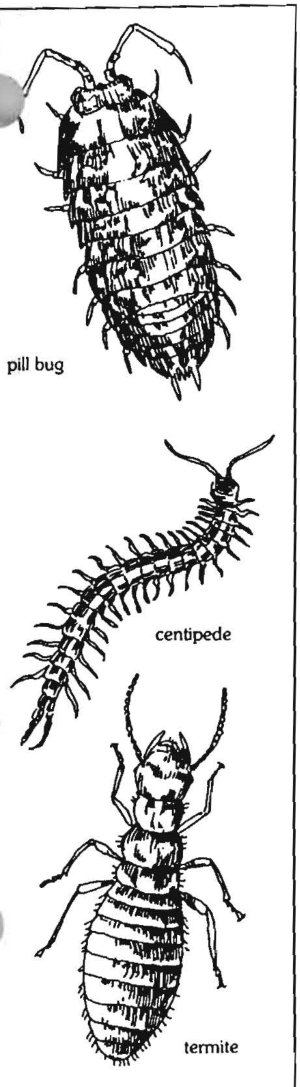
Explain that as a tree grows it collects minerals and other nutrients from the soil and air around it. These nutrients—carbon, nitrogen, phosphorus, and some others—are used by the tree to make new bark, roots, leaves, twigs, and wood. When the tree dies the nutrients become available for animals and other plants to use. And as the nutrients are used, the tree is slowly broken down into *humus*, a dark rich layer of soil. The process of breaking down a tree into its nutrients is called *decomposition.*

Now ask the kids what parts of a tree might become part of the soil. (all parts) As they give their answers, sprinkle your samples onto the newspaper. (For example, if someone says "leaves" you can pour the leaves out of the paper sack and onto the newspaper.) When you have piled up all of your samples, ask the kids if they think the mess on the newspaper is soil. When they say "no" ask them if they know what is needed to turn it into soil. Then use the following information to explain how decomposition works.

(continued next page)

Bruce Norfleet





FROM DEAD TREE TO SOIL

Many things depend on dead trees for food, shelter, and/or nesting sites. Fungi, bacteria, and wood-eating insects such as termites and some beetles are usually the first to "move into" a dead tree. As they feed on the tree they help soften the wood, and the tunnels of the wood-eating insects provide access routes through which water and other fungi, bacteria, and small animals can enter the tree. Some of the animals lay their eggs in the soft wood and the larvae feed on the wood when they hatch. Others feed on the fungi or animals already living in the dead tree. And some animals make their nests or seek shelter inside decaying trees. As all of these animals excavate, eat, and burrow through trees, they help to break them down. It takes a long time to turn a tree into humus.

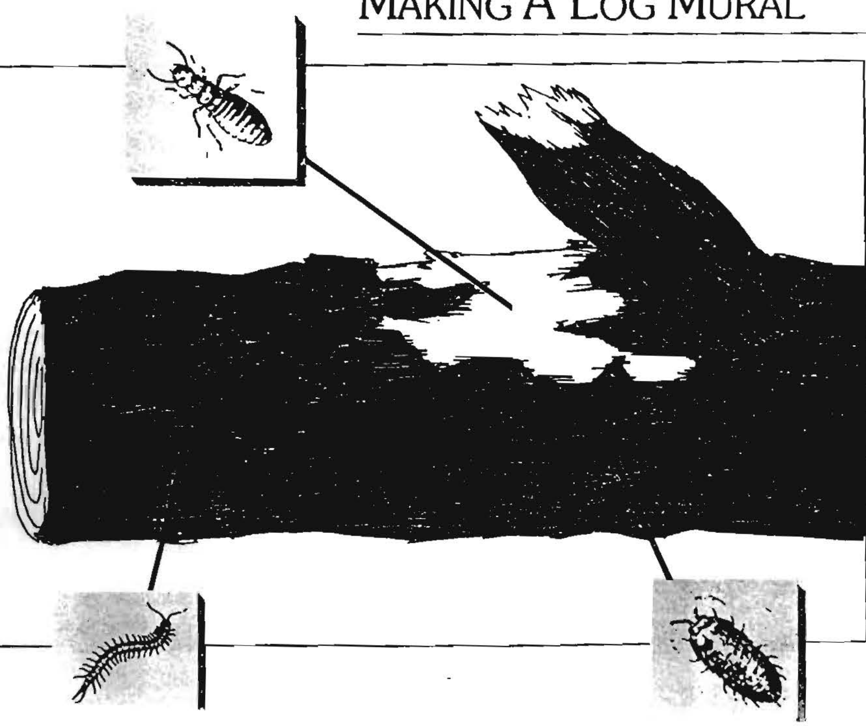
Now tell the kids that they are going to see decomposition in action by examining a rotting log. Before you take the group out, scout around and find an area that has several logs (or large fallen limbs) close together. Then divide the kids into groups of three or four. Give each group some magnifying glasses (one per person, if possible), four or five "bug" boxes or jars with lids, a pencil, markers or crayons, one or two sheets of paper, a clipboard, and some field guides (to insects, spiders, reptiles, and amphibians). (If you don't have clipboards, have the kids use tape, glue, or rubber bands to attach the sheets of paper to pieces of sturdy cardboard.)

Explain to the kids that as they examine the log they should try to find at least one creature from each of these regions: on top of the log, under the bark, and underneath the log or on the ground nearby. They should use the blank sheets of paper to draw the plants, animals, and fungi that they find and write down where on the log they found each one. (Have the kids put the animals they find into jars with lids so they can observe and draw them.)

Then take the kids outside and let each group choose a log to study. (Or let several groups work together on one log.) Explain that they'll be using their drawings later to make a mural. *Note:* Before taking the kids out, be sure to set your own safety guidelines, such as: "Do not stick bare hands into dark holes, release all of the animals after observing and sketching them, and replace the log in its original position after examining it."

Afterward, go back inside and have each group explain what they found. Then set up a log mural. Here's how:

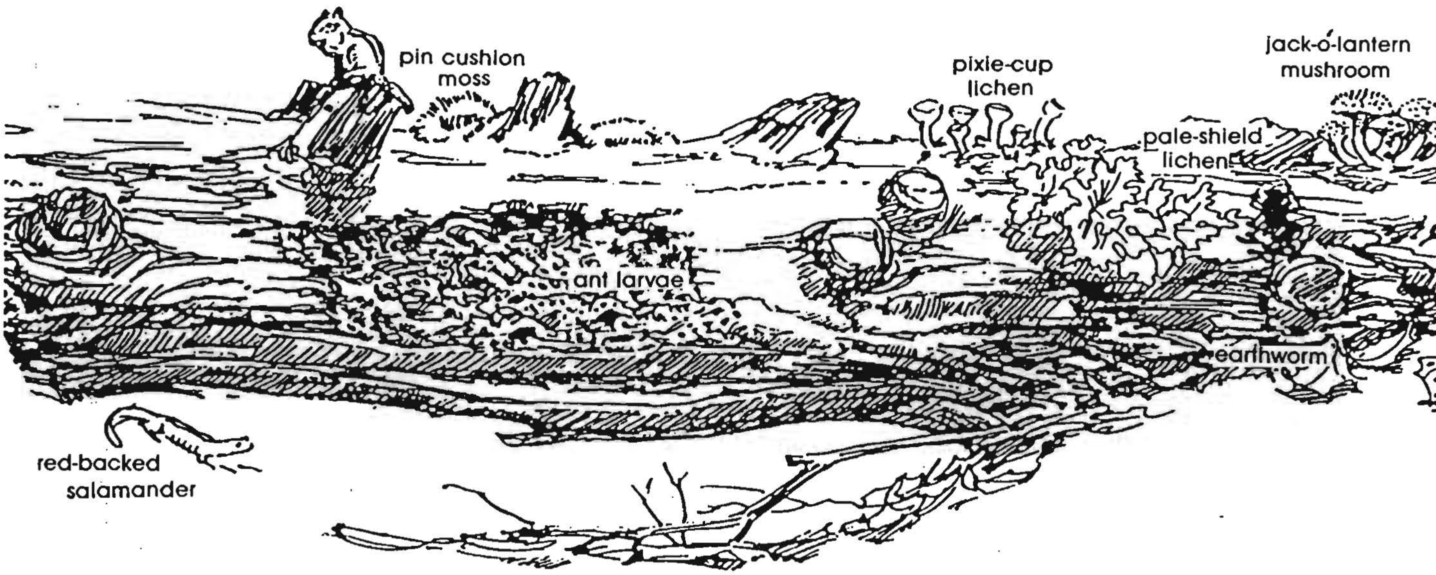
MAKING A LOG MURAL



1. Tape several large pieces of easel paper together, draw a log on the paper, and then hang the picture on a bulletin board or wall.
2. Cut out the drawings the kids made outside, and glue them onto separate pieces of construction paper.
3. Tape the drawings around the log and then use pieces of yarn to connect each picture to the area on the log where the animals were found (see diagram).

Life on a Rotting Log

Name ____________________



The forest community is not limited to animals and plants that live in or near living trees. As the succession of the forest continues, many trees will die and fall to the ground. As the "dead" log lies on the forest floor, the actions of plants, animals, bacteria, lichens and the weather help break it down and return its components to the forest soil. Notice the many different varieties of life found on the rotting log.

1. List the different kinds of plant life that are found on the rotting log. ____________________

2. How do the small plants help this log to decay? ____________________

3. What do the plants get from the log? ____________________

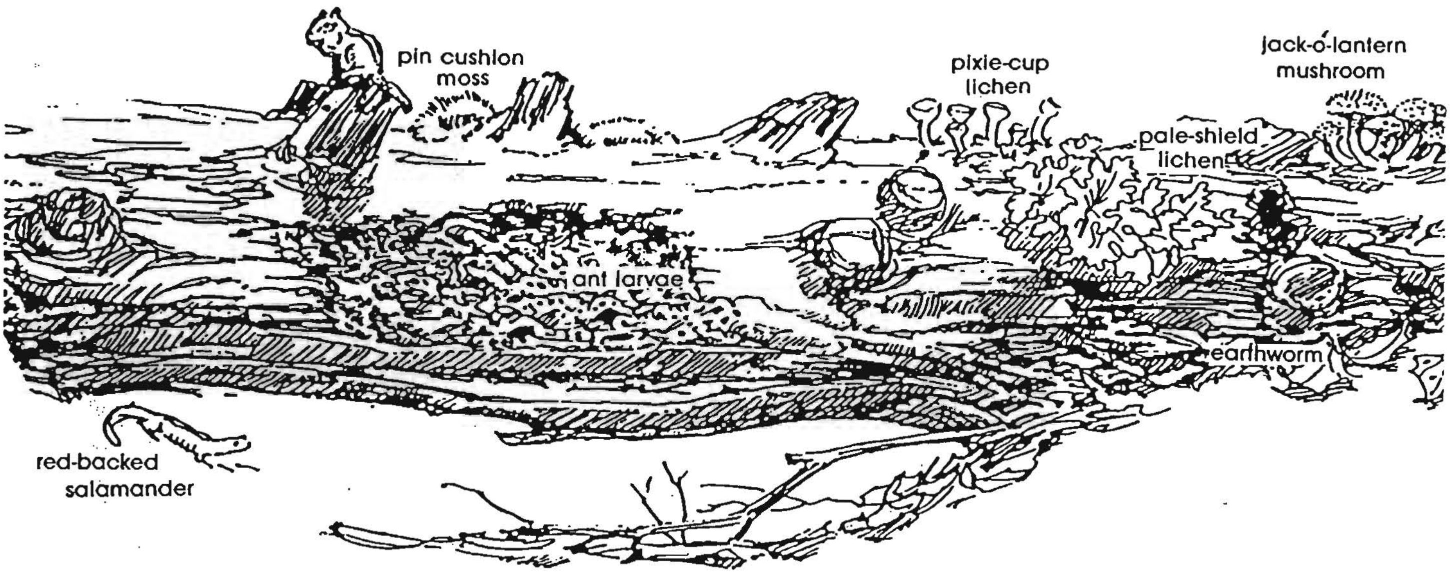
4. What kinds of small animals are found in or on the rotting log? ____________________

5. How do these animals help the log to decay? ____________________

Find Out! — The lichen found on the rotting log is a very interesting kind of plant. It is actually two organisms that are living together. What two organisms form lichen? What does each of these organisms need to live? How do organisms help each other?

Life on a Rotting Log

Name KEY



The forest community is not limited to animals and plants that live in or near living trees. As the succession of the forest continues, many trees will die and fall to the ground. As the "dead" log lies on the forest floor, the actions of plants, animals, bacteria, lichens and the weather help break it down and return its components to the forest soil. Notice the many different varieties of life found on the rotting log.

1. List the different kinds of plant life that are found on the rotting log. lichen, moss, jack-o-latern mushroom (decomposers)

2. How do the small plants help this log to decay? the roots on the plants work into the log and open small spaces, which break the log down

3. What do the plants get from the log? the plants (decomposers) find food, a place to grow, and protection on the rotting log

4. What kinds of small animals are found in or on the rotting log? chipmunk, red-backed salamander, ants, earthworms

5. How do these animals help the log to decay? the animals eat parts of the log or chew on it

Find Out! — The lichen found on the rotting log is a very interesting kind of plant. It is actually two organisms that are living together. What two organisms form lichen? What does each of these organisms need to live? How do organisms help each other?

Lichen are made of algae and fungi. The fungi absorbs the water that the algae needs to live. The algae make the food by means of photosynthesis.

A Study of the Forest Floor

Name ____________________

Most often a forest habitat is cool, damp and shady. When you first look, it might seem that plant life is less abundant than it would be in a pond or grassland area. But as you look more closely you will see many kinds of species that love shade, such as horsetails, mosses, ferns and fungi. The soil of a forest floor is rich in decaying matter. Its acidity will depend upon whether it contains fallen evergreen needles which increase the acidity or leaves from deciduous trees. This rich soil will be home to many kinds of animals including earthworms, centipedes, snails and beetles.

You are going to study a forest floor, either on your own or on a field trip. You will need a wire hanger. Bend it into a circle. Toss the circle in a forest. Watch out for trees! Answer these questions and complete the activities as you examine the living things in your own tiny forest plot.

What is the temperature inside your plot? __________ Is it dry or moist? __________

Identify and describe all the plants that are in your plot. ______________________________

____

____

Sketch the ones you cannot identify in the boxes below.

Look for animals. Look under any leaves, evergreen needles or twigs. Identify and describe the different animals that you find. ______________________________

____

____

Sketch the ones you cannot identify in the boxes below.

Do the same thing with the hanger either on your lawn or in a field near your home. Compare that habitat with your findings in the forest.

REPORT OF WEATHER CONDITIONS FOR MICRO-PLOT STUDIES

MONTH ________ DAY ________ TIME ________ a.m./p.m.

TEMPERATURE ________________________________

RELATIVE HUMIDITY ________________________________

WIND DIRECTION ________________________________

PRECIPITATION ________________________________

SKY (clear, cloudy, etc.) ________________________________

REMARKS ________________________________

____

____

____

____

____

____

____

THINGS TO LOOK FOR IN YOUR MICROPLOT STUDY AREA

1.) General discription of area (size, where it is, etc.) ____________

2.) Intensity of sunlight (bright sun, shaded, etc.) ____________

3.) Water availability (Is the area in a wet or dry location?) ____________

4.) Soil characteristics

a.) What does it feel like? (sand, clay, etc.) ____________

b.) What does it smell like? ____________

c.) Amount of moisture in soil (dry, damp or wet) ____________

d.) Can you pack it into a tight ball? ____________

e.) How is the soil important to your area? ____________

5.) Plants

a.) What percentage of your area is covered by plants? ____________

b.) What kind of plants can you find? (moss, fungus, grass, flowers, trees, etc.) ____________

c.) What colors can you find in the plants? ____________________

____

d.) How are the plants important to your area? ____________________

____

____

____

6.) Animals

a.) What kind of animals are in your area? (insects, worms, snails, birds, etc.) ____________________

____

b.) What animal signs can you find? (holes, tracks, dropping, hair, feathers, etc.) ____________________

____

____

c.) What other kinds of animals do you think might be found in this kind of area? ____________________

____

____

d.) How are the animals important to your area? ____________________

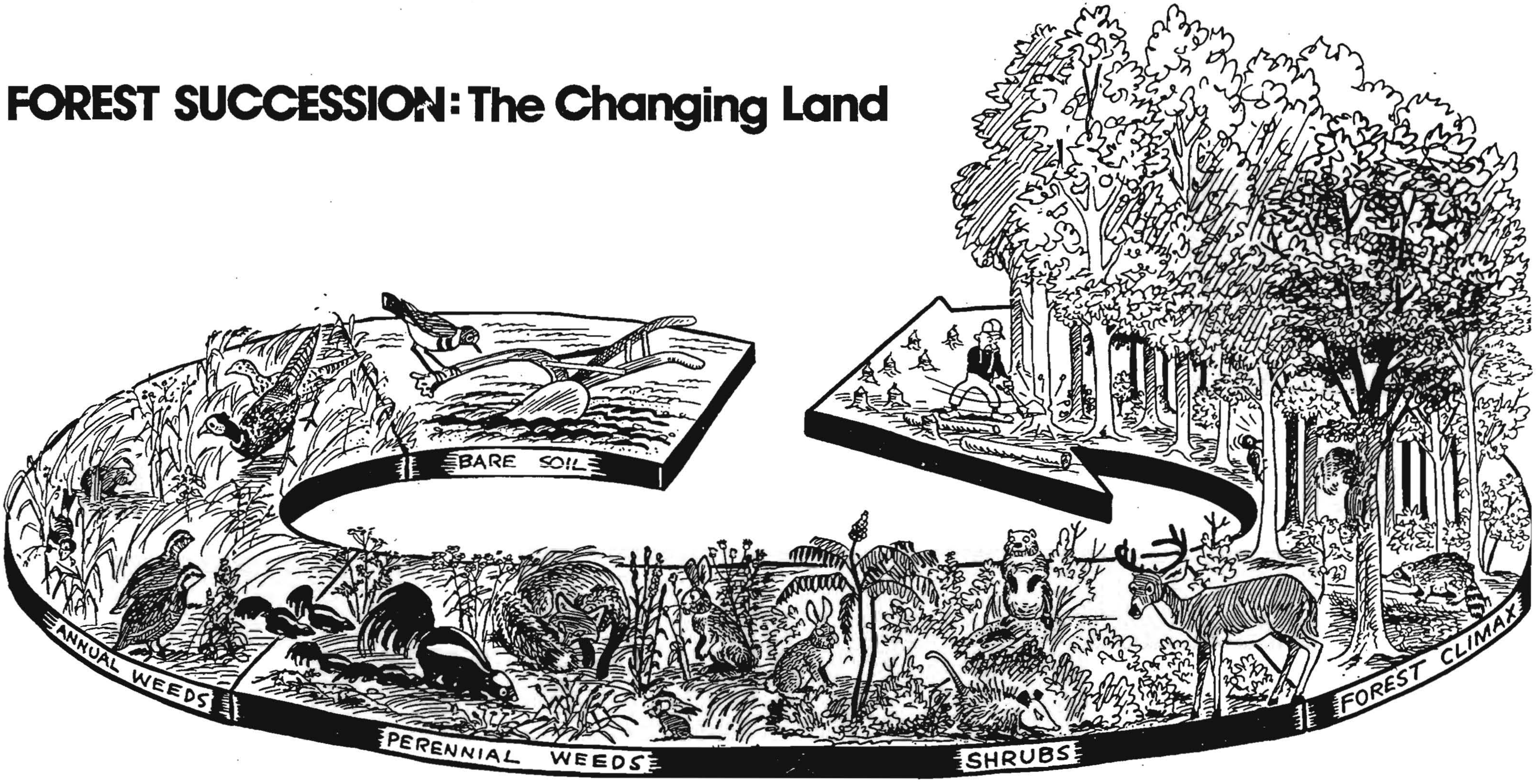
____

____

____

NOTES:

FOREST SUCCESSION: The Changing Land



Michigan Forest Succession

Change. In Michigan our forests have undergone centuries of change. This change is called **Succession,** the orderly replacement of one plant community by another. Along with the plant communities, the wildlife that inhabits these areas will change, too. This change takes place over a long period of time and can occur naturally or with human interference.

Long before Michigan was settled, our state was covered almost entirely by forests. On occasion a bolt of lightning would ignite a forest fire and the burned timber would create a place for a new plant community. The same would happen if an ice storm or tornado destroyed parts of the forest. As the new plant community became established, the wildlife adapted to the change.

As Michigan began to become more populated and settlement occurred, it was human interference that added a new dimension to succession. It was the axe, plow, and saw that changed the established forest communities. The building of towns, creation of farms, and logging of forests accelerated succession. Natural succession is good and because it takes time, most wildlife can adapt easily. When it occurs at too great a speed, succession can alter the natural habitat of wildlife species before they can adapt. Today forest and wildlife managers are aware of this concept. On the reverse of this page is an example of succession.

In this diagram, a farm has been deserted leaving only bare soil behind. Soon weeds spring up everywhere. Weeds are extremely important plants because they readily adapt to disturbance and rush in to fill a vacated niche. As the weeds become established they keep the soil from eroding. Without weeds, both wind and rain combine to remove the soil from the land. Without weeds, some of the rain that does fall quickly evaporates. The new weeds hold the moisture in place. As weeds die, their nutrients enrich the soil. Not many forms of wildlife live in bare soil, but as the weeds are taking over they produce food for seed-eating animals. Mice, gophers, quail, and pheasant are just a few of these.

After about fifteen years, the area now becomes dominated by shrubs. These sun-loving species of dogwood, sumac, blackberry, and hawthorn gradually replace many of the weeds and grasses. New mammals and birds (rabbits, groundhogs, bluebirds, etc.) that prefer more cover and eat parts of these plants will become more abundant. These animals bring new seeds along with them. Some of these seeds may have been eaten somewhere else, but are deposited here. Other seeds hitchhike on animals due to a prickly outer covering. Some seeds, such as acorns, may be deposited by squirrels from an adjacent forest. And, of course, many seeds arrive by the wind.

These new seeds may include some sun-loving tree species like aspen, black cherry, sassafras, or jack pine. These trees are often referred to as **pioneers** because they are the first trees to venture into these unclaimed territories. Pioneers love the sunlight and soon grow above the shrubs and now-disappearing weeds that cannot compete. The whitetail deer and ruffed grouse do exceptionally well in these early stages of pioneer species growth. After 35 years this young forest looks nothing like the farmland it had once been.

But succession doesn't stop there. Dependent on soil type, moisture, and seed availability, new species continue to move in and replace others. The young sun-loving pioneers will eventually have a difficult time replacing themselves in the now-shaded understory. Trees more tolerant of shade will become established. Oaks, hickorys, beech, and sugar maple can grow in less sunlight. In several hundred years, an initial forest of aspen and cherry may become a forest of sugar maple and beech.

As this forest become older, different wildlife species will choose it for habitat. If the browse line becomes too high and the forest floor too shaded for ground cover plants, the deer will become less abundant. Cavity-nesting animals drawn to older trees with decaying wood will be more common. Woodpeckers, raccoons, and squirrels are examples of these. The forest that grows old and allows only more of its own shade tolerant kind to grow is referred to as a **climax** forest. It may remain a climax forest for a very long time unless a farmer returns to cut down the trees, pull the stumps, and plow the soil. Remember, this is how our diagram began.

As we have seen, succession does not happen overnight. Yet, if you are observant, you can see the difference in plant communities and understand that wildlife is dependent of them. The meadow that children play baseball in today will no doubt grow into a forest tomorrow. It's only a matter of time. . . and change.

MUCC

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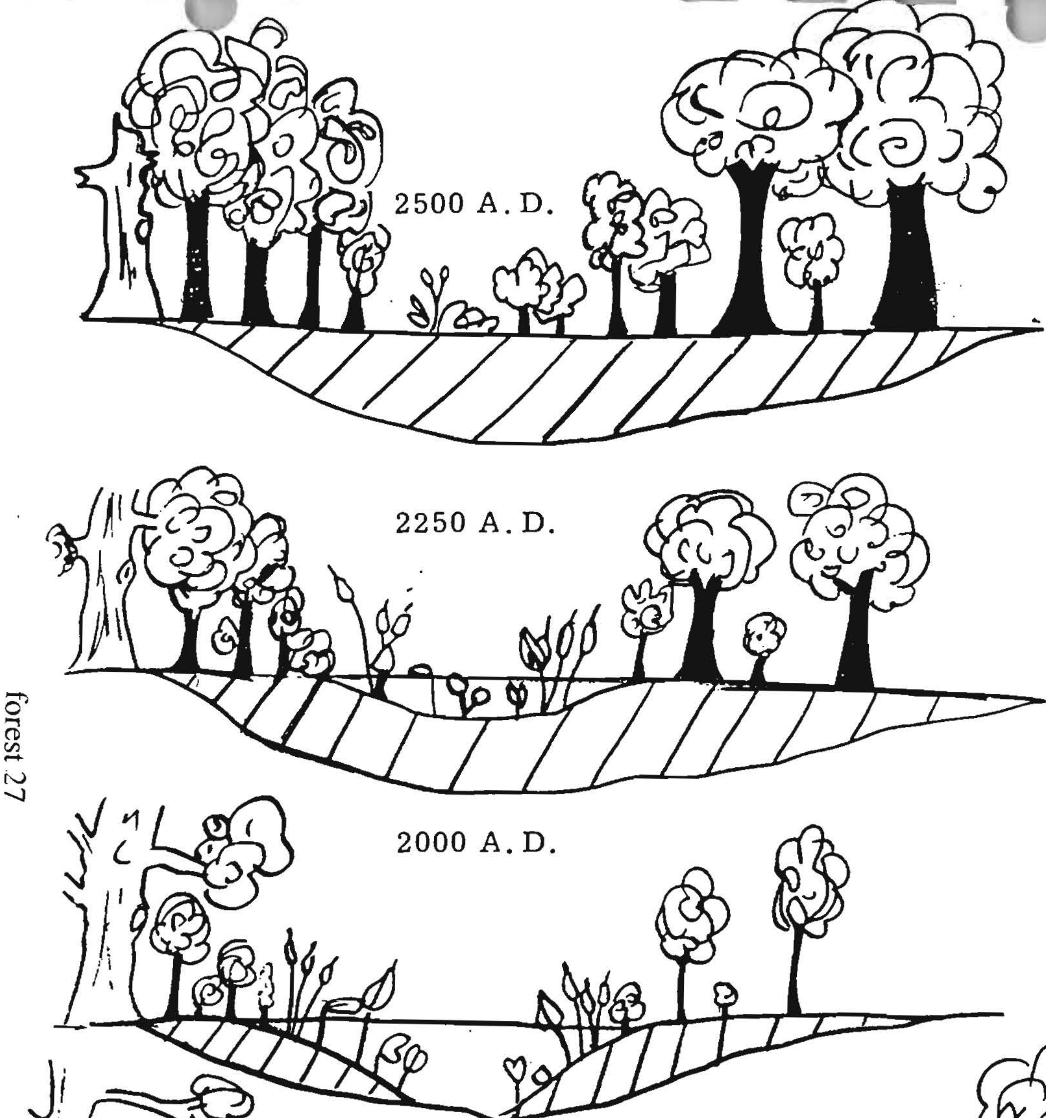
2101 Wood St. ● P.O. Box 30235 ● Lansing, MI 48909 ● 517-371-1041

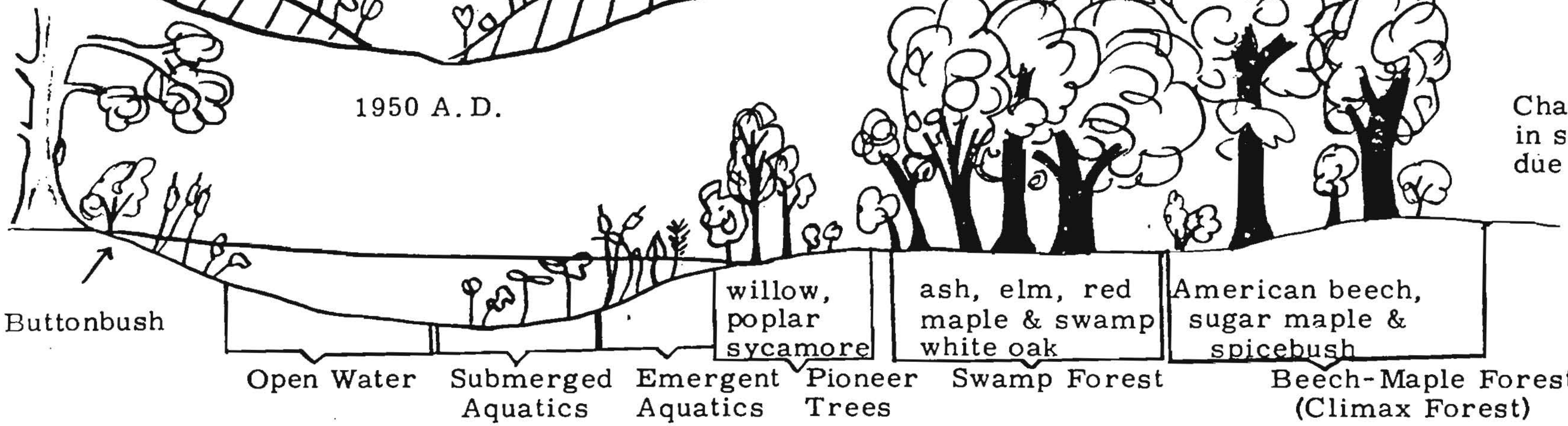
PLANT SUCCESSION

A plant community has some plants which tend to control and dominate the community. These are called dominate species. Other plants in the community are called secondary or associates. A plant community usually is named for its dominate species. When one plant community borders on another, there is no clear dividing line. Instead, there is a transition zone or ecotone where communities overlap. At Blacklick Woods Metropolitan Park, where both swamp forest and beech-maple forest occur, there are many areas with elm, ash, and red maple of the swamp forest, and American beech and sugar maple of the beech-maple forest, all about equally intermixed.



Horizontal Succession

Change of an area in space usually due to topography.



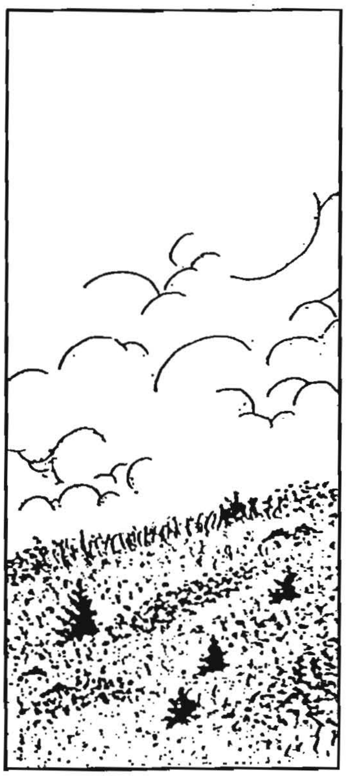
forest 27

From Field to Forest

Name ____________________

Through a series of changes, an abandoned farmer's field can develop into a climax forest. These changes take an orderly pattern as each new plant or animal population makes environmental changes for the new plants and animals that will succeed them. This series of orderly changes is called succession.

Read the description of each step of the succession of an abandoned farmer's field in the Southeastern United States.



Farmer's Abandoned Field

Ten years after Farmer Brown quit working his farm, small pine seedlings began to grow in the abandoned field along with low-growing shrubs, grasses and herbs.

List some animals that would live in this habitat.

____

____

____

Pine Forest

Twenty-five years have passed and the pines have grown tall and mature. Young oak trees start to grow beneath the pines.

List some animals that would live in this habitat.

____

____

____

____

Oak-Pine Forest

The oak trees reach for the sun between the old pine trees. Many older pines die, and young oaks begin to replace the pines.

List some animals that would live in this habitat.

____

____

____

____

Oak Climax Forest

The large oaks dominate the forest. Young oaks grow in the understory, while young pines cannot grow in the shade of the oaks.

List some animals that would live in this habitat.

____

____

____

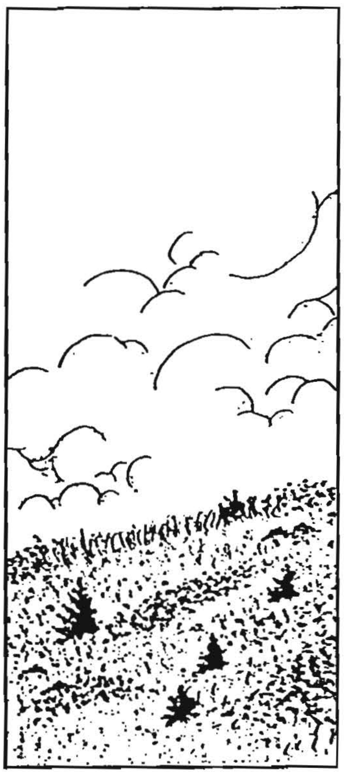
____

From Field to Forest

Name KEY

Through a series of changes, an abandoned farmer's field can develop into a climax forest. These changes take an orderly pattern as each new plant or animal population makes environmental changes for the new plants and animals that will succeed them. This series of orderly changes is called succession.

Read the description of each step of the succession of an abandoned farmer's field in the Southeastern United States.



Farmer's Abandoned Field

Ten years after Farmer Brown quit working his farm, small pine seedlings began to grow in the abandoned field along with low-growing shrubs, grasses and herbs.

List some animals that would live in this habitat.

mice hawks
rabbits snakes
groundhog

Pine Forest

Twenty-five years have passed and the pines have grown tall and mature. Young oak trees start to grow beneath the pines.

List some animals that would live in this habitat.

deer
woodpeckers
chipmunk

Oak-Pine Forest

The oak trees reach for the sun between the old pine trees. Many older pines die, and young oaks begin to replace the pines.

List some animals that would live in this habitat.

squirrels
raccoon
fox

Oak Climax Forest

The large oaks dominate the forest. Young oaks grow in the understory, while young pines cannot grow in the shade of the oaks.

List some animals that would live in this habitat.

turkey
grouse
squirrel

FOREST IN A JAR

Objectives

Students will be able to: 1) observe and describe succession; and 2) summarize what they have learned about how environments can change.

Method

Students conduct an experiment using soil, water, seeds, a plant, and a jar; and then draw a poster to represent their observations and findings.

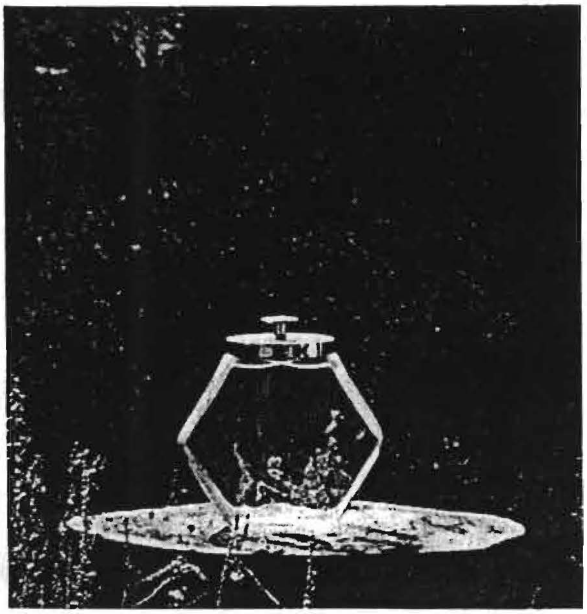
Background

Succession is a term used to describe the ever-changing environment and the gradual process by which one habitat is replaced by another. Many habitats that appear to be stable are changing before us. In this activity, students will be able to see in miniature how a swampy area can be succeeded by a forested habitat.

The major purpose of this activity is for students to recognize the process of succession.

Materials

pint or quart jars (one per student or small groups of students, or one for the entire class), water, soil, aquatic plants (one per jar), two cups bird seed



Procedure

1. Place two inches of soil and three inches of water in a jar. Place the jar at a window, **without a lid**, and allow it to settle overnight.
2. Plant an aquatic plant in the jar. It should grow well in this environment. If your classroom has no windows, substitute a grow-light.
3. Do **not** replace the water that evaporates from the jar.
4. Once or twice a week, have students add three or four bird seeds to the jar. While there is water in the jar, the seeds should germinate and then rot. Continue adding seeds even after the water evaporates.
5. As the water evaporates down to the soil, the aquatic plant will die. The bird seeds will now find the environment suitable for successful growth. Sunflower seeds, which grow large, can be added to represent forest trees. You will now need to add water, as a substitute for rainfall, to keep the soil damp to keep things growing.
6. Have each student make a poster, drawing, or other visual representation of what they saw happen to their "pond." Ask them to talk about what they have learned about how environments can change. Introduce the term, "succession," to older students.
7. OPTIONAL: Take a field trip to a pond. What plants are growing in the water? What plants are growing on the shore? What parallels are there between this real pond and the "pond" in the jar? Make a second drawing of this real pond. Compare the similarities and differences between the two.

NOTE: See "Pond Succession," and use it as an extension to this activity.

Age: Grades K—6
Subject: Science
Skills: analysis, application, comparing similarities and differences, description, discussion, drawing, generalization, invention, media construction, psychomotor development, research
Duration: five to ten minutes for one or two days a week for several weeks; 20 to 30 minutes for summary activity
Group Size: any
Setting: indoors; outdoors optional
Conceptual Framework Reference: III.A., III.A.1., III.A.3., III.B., III.C., III.C.1., III.C.3., III.C.4.
Key Vocabulary: evaporation, change, succession

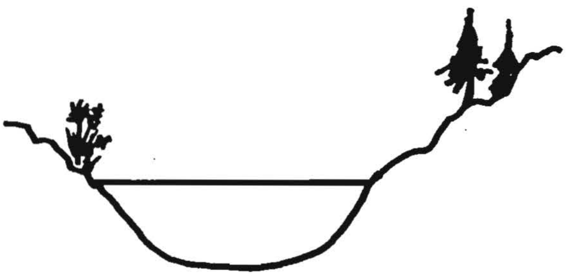
Evaluation

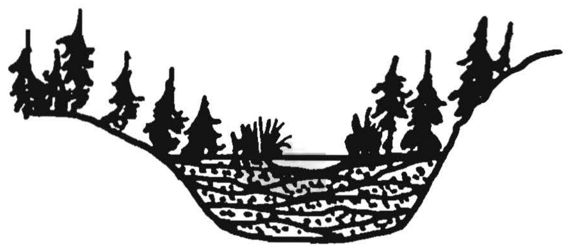
Describe three changes you saw happen to what was inside the jar.

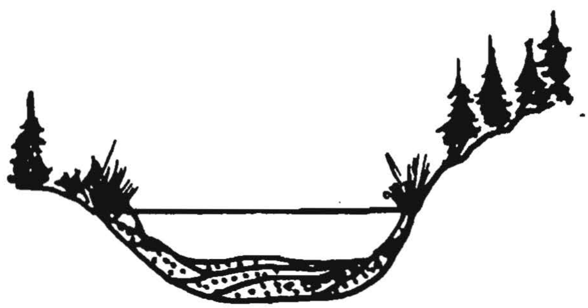
Number these drawings to show their order from what would be most likely to be first, to what would be likely to last.

Draw lines from each of these animal names to the places above where they would be most likely to live.

fish turtle raccoon squirrel deer







APPENDIX

Questions, Questions, and More Questions

1. True or false: Trees are considered to be annuals. (False. Annuals are plants that sprout, reproduce, and die in one season. Trees, though, are a type of perennial, which means they live for many seasons.)
2. True or false: Gymnosperms do not produce true flowers or fruit. (True)
3. Name a kind of tree that's a gymnosperm. (Spruces, firs, pines, hemlocks, redwoods, and other conifers are all gymnosperms.)
4. What are deciduous trees? (trees that lose their leaves each year)
5. A tree's outer covering, or ___, protects it from injury, insect damage, and disease. (bark)
6. The sapwood carries ___ and ___ from the roots to the leaves. (nutrients, water)
7. True or false: Pine needles are leaves. (True)
8. What gives green plants their green color? (a pigment called chlorophyll)
9. Name five products people get from trees. (lumber, paper, food, spices, rubber, cork, drugs, fabric—for more examples see pages 65 and 66)
10. The science of managing forests is called ___. (forestry)
11. List three plant layers found in many forests. (canopy, understory, shrub, herb, forest floor, tree trunk, emergent)
12. True or false: Many wild animals spend most of their time in only one or two layers of a forest. (True).
13. True or false: Evergreen trees never shed their leaves. (False. Most evergreen trees gradually replace their leaves, shedding some every year.)
14. Name one function of a tree's trunk. (support rod, transport system)
15. True or false: Broad-leaved trees are also called softwoods. (False. Broad-leaved trees are also called hardwoods. Needle-leaved trees are called softwoods.)
16. Some scientists have divided the world's forests into four major groups. What are they? (boreal, mixed, deciduous, tropical)
17. What is a compound leaf? (a leaf made up of many leaflets)
18. True or false: All broad-leaved trees are deciduous. (False. Some broad-leaved trees are evergreens and do not drop all their leaves each year.)
19. In which leaf layer are stomata found? (epidermis)
20. What two layers make up a leaf's mesophyll? (spongy, palisade)
21. Why do many deciduous trees' leaves change from green to other colors in fall? (In fall chlorophyll breaks down and other pigments in the leaves become visible.)
22. What are coppiced trees? (trees that grow from the stumps of felled trees)
23. What is a decomposer? (an organism that helps break down dead tissue and turns it into soil)
24. What are pulpwood trees? (trees that will one day be made into paper)
25. The inner bark, or ___, transports water, sugar, and dissolved nutrients to all parts of a tree. (phloem)
26. Name two ways animals use trees. (for food, shelter, nesting sites)

Deer of Sharon Woods

Objectives:
- Understand the basic needs of living things
- Identify how animals have adapted to their changing environment
- Identify and describe the effects of human activity on the environment
- Read and interpret data and graphs

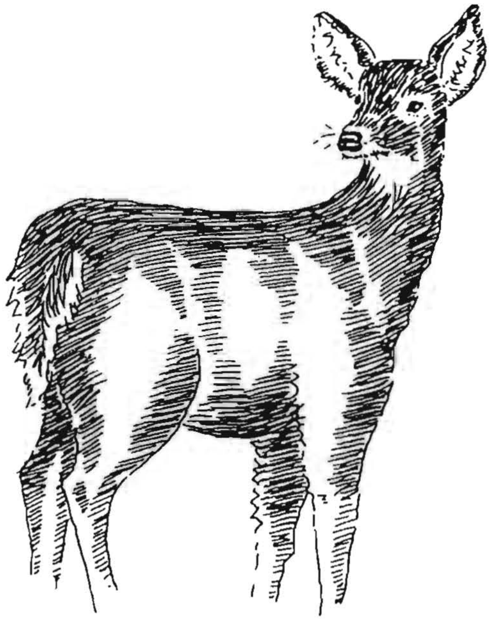
What to Teach	Teaching Suggestions
Introduce students to the white-tailed deer of Ohio.	-Show pictures of deer if possible - Question students about their sightings and interactions with deer in Ohio
Discuss the white-tailed deer with students, in one form or another. The following are common questions about deer:	- Refer to the information sheets provided, "White-tailed Deer" "White-tailed Deer in Ohio" "The Year of the Antler" and "Aging Deer."
1. How did the deer get its name "white-tail"?	1. From its large white tail that is flipped up when alarmed, called the "flag".
2. What are mature male deer called, mature female deer, and baby deer?	2. Males are bucks, females are does, and babies are fawns.
3. How big are deer?	3. Males weigh 130-200 pounds, females weigh 120-150 pounds.
4. How long do deer live?	4. Average age is 3 years old.
5. What do deer eat?	5. Grass, herbs, succulent woody vegetation, acorns, and fruits.
6. When is the best time to see deer?	6. Most active at sunrise and sunset.
7. What type of habitat do they like?	7. Mix of forests, brushland, and cropland.

What to Teach	Teaching Suggestions
8. Do they make sounds?	8. Thirteen sounds are recognized, including snorts, whistles, grunts, and wheezes.
9. What are antlers?	9. Antlers are not horns but outgrowths of the skin. Antlers are covered with "velvet" while growing and later harden and become horn-like. At this time the velvet is scraped off. See "The Year of the Antler".
10. Do both females and males have antlers?	10. Only males have antlers.
11. How many fawns do does have?	11. One fawn is born the first year and 2-3 per year after that. Fawns are born in May and June and are on their own by September.
12. Are there more deer in Ohio now than in previous years?	12. YES
13. How do you age a deer?	13. Look at the wear on a deer's teeth to determine age. See "Aging Deer".
Identify the components of deer habitat and discuss what limits deer populations.	- Have students participate in the activity "Oh Deer!" - Define: <u>population</u> <u>limiting factors</u>
Discuss with students, through a problem-solving approach, the deer overpopulation problem that occurred (and is still occurring) in Sharon Woods. Q: Sharon Woods has too many deer. The foliage is decimated. What can we do to solve the problem?	- See "Please Don't Feed the Deer", the deer population graphs, and for teacher information, "The Sharon Woods Deer Problem", which provides tables and statistics on deer numbers.

What to Teach	Teaching Suggestions
Q: Why did overpopulation occur?	- Loss of habitat in the surrounding areas due to urban growth forced deer into Sharon Woods. - Lack of natural predators. - Reduction of control through hunting.
Q: What problems do too many deer pose?	- Increased deer/auto accidents. - Damage to the habitat due to overgrazing. - Loss of plant and wildlife diversity. - Increase of deer diseases and starvation.
Visit to Sharon Woods Metro Park.	**- This program offers information and a hands-on exhibit of items concerning the Metro Parks' deer dilemma. Students will learn how the deer population got out of control and what can be done to slow their growth. We'll also discuss the biology of deer and how they fit into the food chain.**
Discuss deer management.	- Define management. - What is the purpose of management? The purpose is to provide a deer population that will allow maximum recreational opportunities while minimizing conflicts between deer and humans - Who manages the deer in Ohio and how is it done? - See "Deer Management" and "Managing Ohio's Deer Herd"
Student Activity.	- In order for students to better understand management decisions, do the activity "Checks and Balances." - As an assignment, have students finish this section with the activity "Hunting and Wildlife Management"

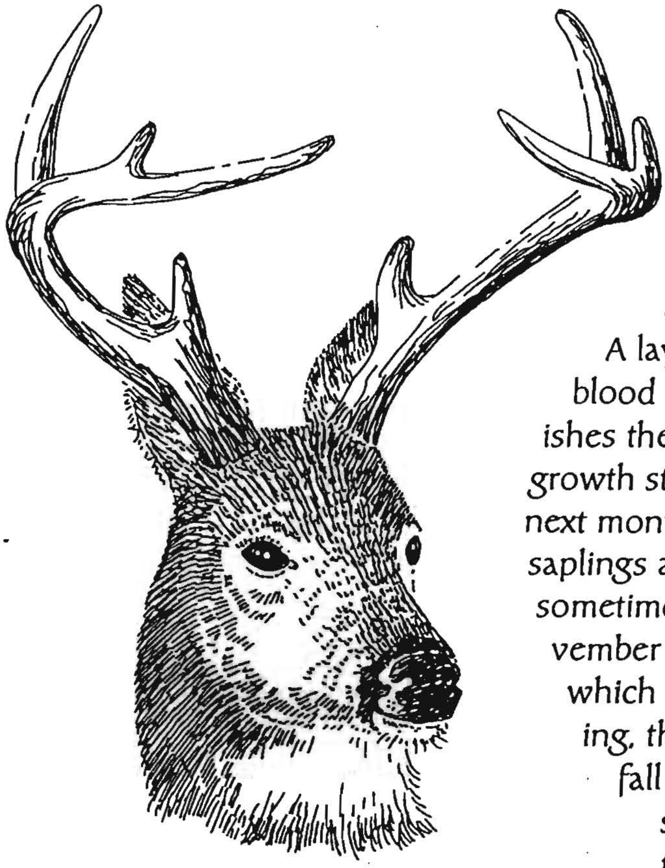
WHITE-TAILED DEER

(Odocoileus virginianus)



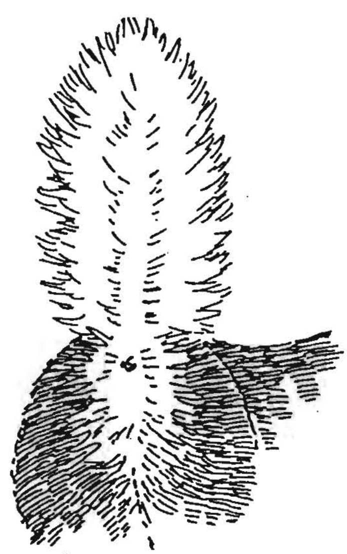
These beautiful animals may be as numerous today as when settlers first arrived in North America. White-tailed deer thrive on the edges of farms, woodlots, and wetlands, areas that provide a variety of food and cover. Deer browse on buds, leaves, and the twigs of woody plants as well as acorns and some farm crops. They are the most important big-game animal of eastern North America.

Fawns have no scent for the first three or four days of life and their beautiful spotted coat blends in with the vegetation. By lying perfectly still in the grass among the shadows and sunlight, a fawn usually remains unseen by predators.



Male deer, called bucks, grow antlers made of solid bone each year. Their antlers display the animal's dominance and sexual attractiveness and are sometimes used to fight off rivals. The antler's size and shape are a result of nutrition, not age. A layer of fuzzy skin, called velvet, containing blood vessels and nerve endings covers and nourishes the antlers as they grow. In late summer growth stops, and the outer skin hardens. Over the next month, males rub off the velvet by attacking saplings and twigs with their antlers, a process that sometimes leaves blood stains on the antlers. November heralds the breeding season, or rut, during which time bucks may behave wildly. After breeding, the shedding process begins, and the antlers fall off sometime between late fall and early spring. Mice, chipmunks, and porcupines eat the antlers, which contain nutritious minerals, calcium, and salt. Some bucks, weakened by growing the large antlers and fighting other deer, may not make it through the winter.

The prominent tail gives the "white-tail" its name. When a deer is alarmed, the tail flips up and fluffs out, providing a large warning signal to other deer.



METROPOLITAN PARK DISTRICT
COLUMBUS AND FRANKLIN COUNTY
P.O. BOX 29169
COLUMBUS, OHIO 43229

WHITE-TAILED DEER

Deer were abundant when the first white settlers arrived in central Ohio, but unregulated hunting and land use changes caused their extirpation by the end of the nineteenth century. However, in the past 50 years, reinvasion of deer from other states and protection under Ohio game laws have resulted in the return of deer to most of the state. Today, central Ohio has a moderate population of white-tailed deer; they occur in all the Metropolitan Parks.

It isn't easy to see them though. Deer manage to be surprisingly unobtrusive for such large animals (a very large buck may weigh more than 300 pounds). Hoofprints, droppings, and other signs may be everywhere, but the most one usually sees is a glimpse of a brown flank and a white tail raised in alarm as the animal bounds away in the underbrush, making a startling crash that is quickly followed by complete silence, as if it had run a few yards and then disappeared in thin air. The disappearance is an illusion, of course--the deer has simply paused at what it considers a safe distance to look back.

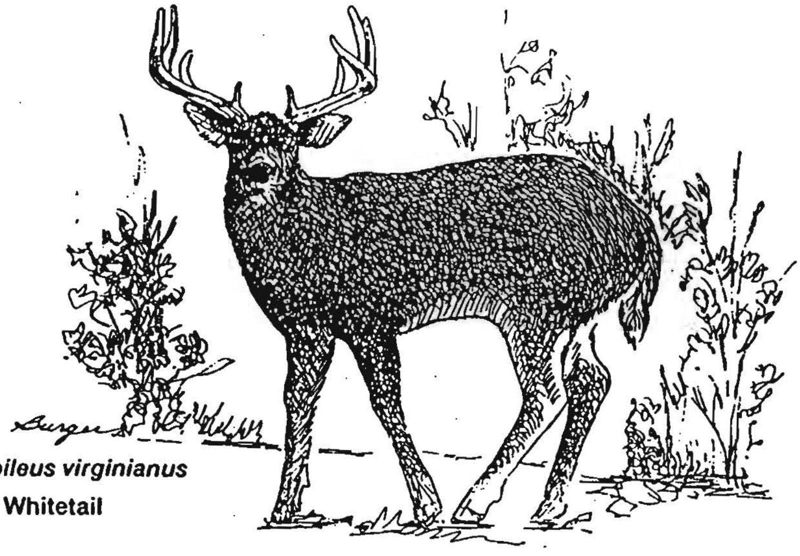
Deer are very curious animals. Even today, in National Parks and in areas where they are not often hunted, they are as likely to approach and investigate a human as run away. In such situations they can be dangerous, since they are unpredictable and capable of dealing fatal blows with their hoofs. Deer have hurt many more people than have wolves, mountain lions, or other carnivores. Buck deer during the mating period--the rut--are extremely dangerous. Fawns should always be left strictly alone, as the mother may attack if she feels her young are threatened.

Whitetail does usually give birth to one fawn in their first breeding season; in later years they normally bear two, occasionally three, and rarely four. Gestation takes about 200 days. Most Ohio fawns are born in May and June. The fawns lie quietly, camouflaged in the leaf litter by their dappled coats, for about a month before they get up and join their mother on her feeding route. Meanwhile, the bucks' antlers have started to grow--knobby, fuzzy growths which at first look more like a strange cactus than antlers. The antlers are not true horns, but outgrowths of the skin, like hair, and do not become hard and horn-like until the fall, when the "velvet" outer covering is scraped off against saplings and tree trunks. Antler size and the number of points are unreliable indicators of a buck's age. A three and one-half year buck may have a much finer rack than a six or seven year old. Wear and replacement of the teeth, which occurs in an orderly progression, is a much more reliable estimator of age.

Males spend the summer companionably in groups of two or three. But when their antlers have hardened, they begin to lower their heads at each other and spar with their new weapons. As the mating season progresses, these rivalries become serious, each buck trying to acquire as many does as he can. Harems are seldom large in central Ohio because of the scattered population. The rutting season runs through December or mid-January, by which time the deer have traded their red summer coats for the dense gray fur of winter. By February, the bucks' antlers have dropped off. Cast-off antlers are found less often than might be expected because they are nibbled on by a multitude of small mammals.

Deer eat a variety of foods, depending on the time of year. In spring, they graze on the green sprouts of grass and other plants. In summer, they eat a wide variety of herbs, grasses, and succulent woody vegetation. Their autumn diet may include large quantities of acorns and other nuts, as well as fruits. Deer may become a nuisance in orchards and vineyards at this time. In winter, deer return to browsing on leaf buds, fruits, seeds, and soft evergreen leaves. They may also eat mosses and lichens.

White-tailed Deer in Ohio



Scientific name: *Odocoileus virginianus*
Other common names: Whitetail

LIFE HISTORY NOTES

Mating: polygamous. **Breeding period:** late October through mid-January; peak of activity in early to mid-November. **Gestation:** 187-222 days; average 200 days. **Birth period:** mid-May through July; peak period in late May through mid-June. **Litters per year:** 1. **Litter size:** 1 in first year; 2 and occasionally 3 in later years. **Birth weight:** male 4-14 lb (1.8-6.4 kg), average 7 lb (3.2 kg); female 3-8 lb (1.4-3.6 kg), average 5 lb (2.3 kg). **Eyes of young open:** at birth. **Young weaned:** at 10 weeks. **Breeding age:** most males at 1½ years, 50-68% of females at 6-8 months. **Adult weight:** male 130-300 lb (59-136 kg); female 120-150 lb (54-68 kg). **Adult body length:** 60-95 inches (152-241 cm). **Adult tail length:** 6-11 inches (15-28 cm). **Life expectancy:** fewer than 5% reach 4½ years. **Movement:** home range ½-2 square miles (130-518 hectares). **Feeding period:** variable; peak activity 3 hours before sunrise to sunrise, and sunset to 4 hours after sunset. **Typical foods:** in decreasing order of occurrence—wild crabapple, corn, sumac leaves and stems, Japanese honeysuckle leaves and stems, grasses, greenbrier fruits and leaves, clover leaves, soybean leaves and beans, jewelweed leaves, acorns, dogwood fruits and stems, and miscellaneous woody browse.

The white-tailed deer is Ohio's largest game animal. The summer pelage is reddish tan and relatively short, thin, and wiry. The winter coat is grayish tan and heavy, with long guard hairs and short, thick underfur that provides excellent insulation. White patches occur on the throat, belly, tail, and insides of the legs. The large white tail, or "flag," is often the most conspicuous part of the deer.

The buck's antlers begin growing in early April, becoming hard and polished by September, and most are shed by early February. Massive racks with many points are indicators of good deer range, where food is plentiful and nutritious. Male fawns have "buttons" which protrude only an inch above the hairline.

Fawns are dropped wherever the doe happens to be at the time. They can walk after one or two hours and they nurse two or three times a day for the first few days after birth, remaining hidden between nursing periods. At about one month the fawns begin to accompany their mother on foraging trips. The family group of mother and fawns stays together until the following spring; occasionally an adult buck can be seen with the group.

Although deer generally pursue life in relative silence, thirteen sounds have been recognized. The most familiar is the snort or whistle of alarm. Others include grunts, wheezes, bawls, bleats, and mews.

In the unbroken virgin forests of early Ohio, whitetails probably were not as numerous as they are today. By 1900, most of Ohio had been converted from forest to cropland; removal of habitat plus unrestricted hunting caused the virtual disappearance of deer from the state by the early 1900s. In the 1920s and '30s, limited stocking combined with natural immigration of deer from adjacent states and enforcement of game laws to build a herd that now occupies every county. About 80 percent of the herd is in unglaciated, hilly eastern Ohio, where deer densities average 5 to 15 per square mile. In the glaciated western and northeast regions, densities vary from less than one to about five per square mile.

Although classified as forest mammals, whitetails do best in habitats with diverse food and cover types, including different-aged timber stands. Ideal habitat management will provide a mixture of forest, brushland, and cropland in blocks of one to two square miles.

DEPARTMENT OF NATURAL RESOURCES OHIO DIVISION OF WILDLIFE

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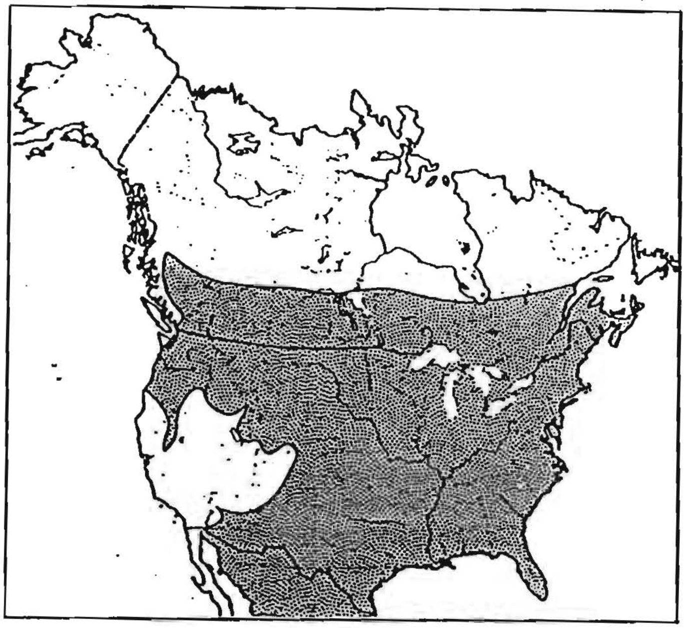
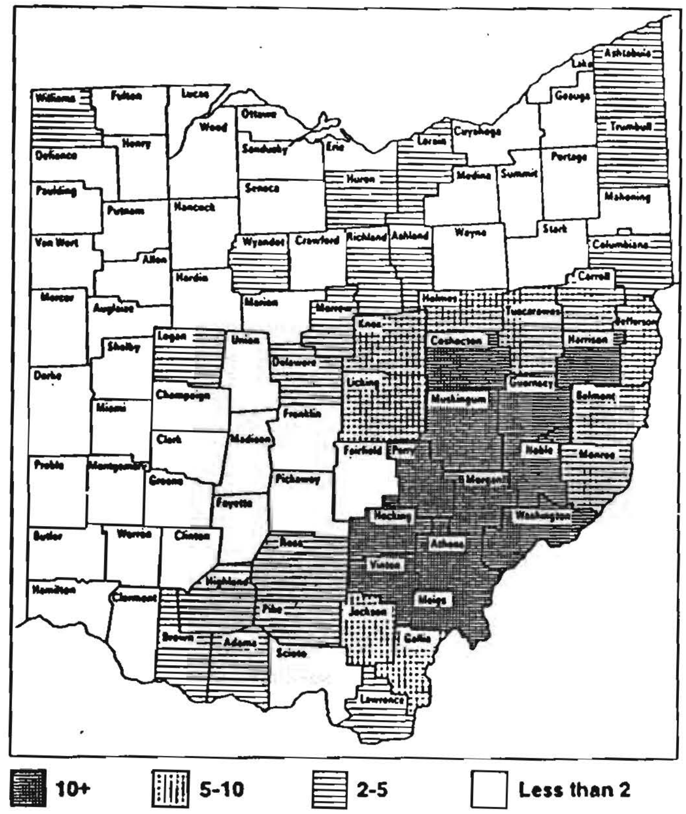
Sportsmen and nature lovers generally look with favor on the whitetail, but an excessive deer population can be an economic menace to the farmer and forester, and a hazard to the motorist. Overabundant deer can also deteriorate their habitat, leading to poor reproduction and physical condition and, eventually, to losses from starvation.

For these reasons, Ohio's deer herd requires management; the legal harvest has proven to be the only effective means. The herd today provides countless hours of recreation to more than 250,000 Ohio sportsmen and—to the one in five who is successful—many excellent meals.

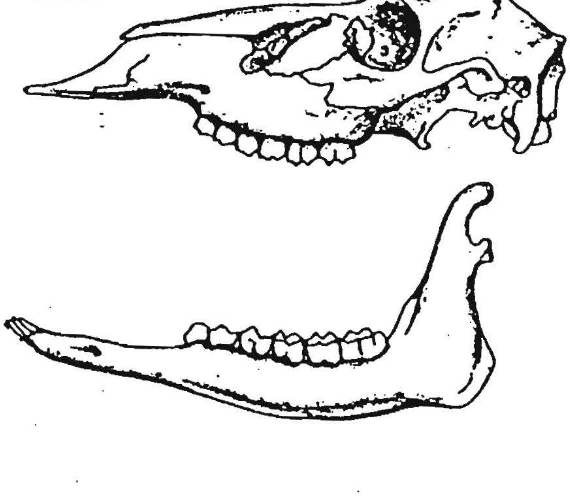
North American Distribution

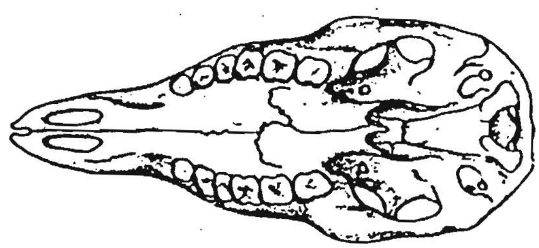


Deer per Square Mile in the Fall



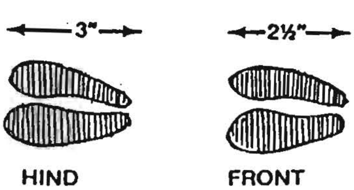
SKULL



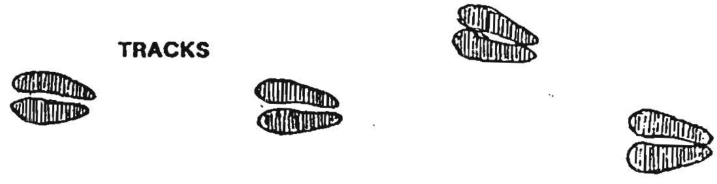


DENTAL FORMULA (32 teeth)

	Incisors	Canines	Premolars	Molars
Upper	0	0	3	3
Lower	3	1	3	3



TRACKS



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THE YEAR OF THE ANTLER

SPRING
Every spring, buck deer grow a new pair of antlers from permanent bumps on their head.

EARLY SUMMER
Antlers are soft and covered with a thin, fuzzy skin called velvet. Velvet contains blood vessels which carry nutrients for building strong bones.

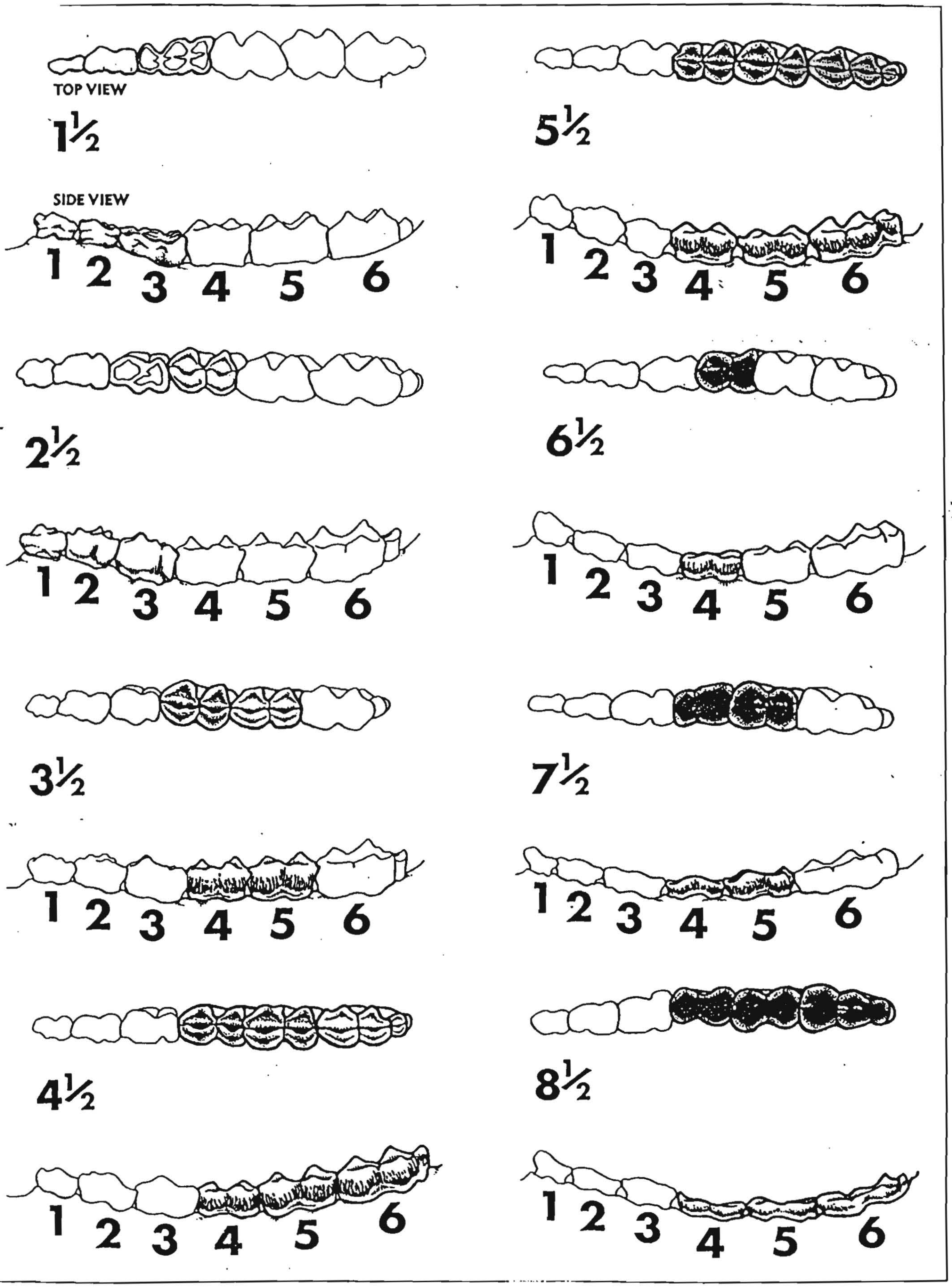
MID SUMMER
By mid summer, antlers are just partially grown.

LATE SUMMER
By late summer the antlers have reached full size. They remain covered with velvet until the bone becomes solid.

FALL
By Fall, antlers are hard. The velvet no longer provides nutrients to the bone and it sheds off.

WINTER
After the fall rutting (mating) season the antlers are no longer needed and fall off. Sometimes it is possible to find antlers in the forest.

Aging Deer



TOP VIEW
1½
SIDE VIEW
1 2 3 4 5 6
2½
1 2 3 4 5 6
3½
1 2 3 4 5 6
4½
1 2 3 4 5 6
5½
1 2 3 4 5 6
6½
1 2 3 4 5 6
7½
1 2 3 4 5 6
8½
1 2 3 4 5 6

OH DEER!

Objectives

Students will be able to: 1) identify and describe food, water, and shelter as three essential components of habitat; 2) describe the importance of good habitat for animals; 3) define "limiting factors" and give examples; and 4) recognize that some fluctuations in wildlife populations are natural as ecological systems undergo a constant change.

Method

Students become "deer" and components of habitat in a highly-involving physical activity.

Background

A variety of factors affects the ability of wildlife to successfully reproduce and to maintain their populations over time. Disease, predator/prey relationships, varying impacts of weather conditions from season to season (e.g., early freezing, heavy snows, flooding, drought), accidents, environmental pollution, and habitat destruction and degradation are among these factors.

Some naturally-caused as well as culturally-induced limiting factors serve to prevent wildlife populations from reproducing in numbers greater than their habitat can support. An excess of such limiting factors, however, leads to threatening, endangering, and eliminating whole species of animals.

The most fundamental of life's necessities for any animal are food, water, shelter, and space in a suitable arrangement. Without these essential components, animal cannot survive.

This activity is designed for students to learn that:

a) good habitat is the key to wildlife survival;
b) a population will continue to increase in size until some limiting factors are imposed;
c) limiting factors contribute to fluctuations in wildlife populations; and
d) nature is never in "balance," but is constantly changing.

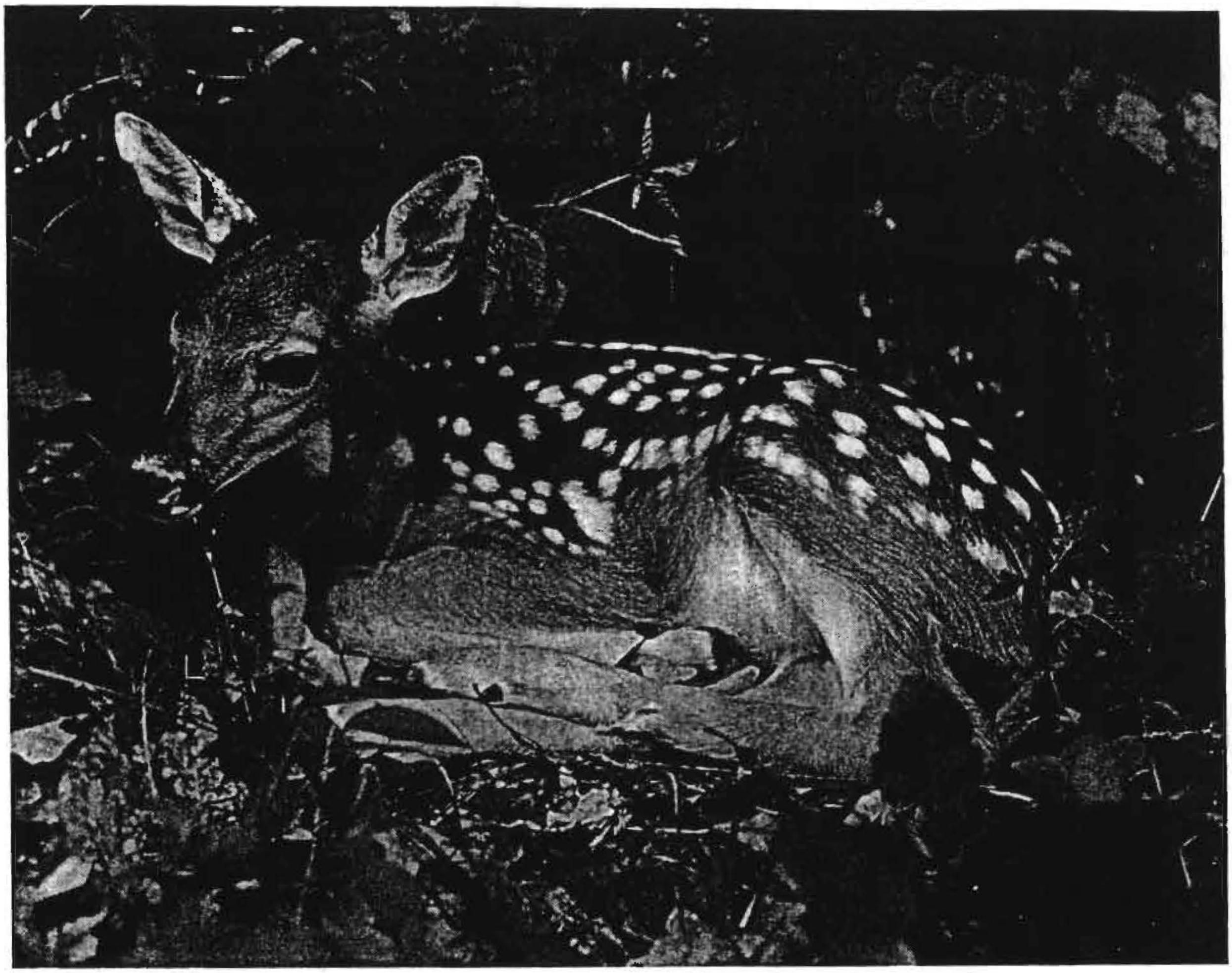
Wildlife populations are not static. They continuously fluctuate in response to a variety of stimulating and limiting factors. We tend to speak of limiting factors as applying to a single species, although one factor may affect many species. Natural limiting factors, or those modeled after factors in natural systems, tend to maintain populations of species at levels within predictable ranges. This kind of "balance in nature" is not static, but is more like a teeter-totter than a balance. Some species fluctuate or cycle annually. Quail, for example, may start with a population of 100 pairs in early spring; grow to a population of 1200 birds by late spring; and decline slowly to a winter population of 100 pairs again. This cycle appears to be almost totally controlled by the habitat components of food, water, shelter, and space, which are also limiting factors. Habitat components are the most fundamental and thereby the most critical of limiting factors in most natural settings.

This activity is intended to be a simple but powerful way for students to grasp some basic concepts: that everything in natural systems is interrelated; that populations of organisms are continuously affected by elements of their environment; and that populations of animals do not stay at the same static number year after year in their environment, but rather are continually changing in a process of maintaining dynamic equilibria in natural systems. The major purpose of this activity is for students to understand the importance of suitable habitat as well as factors that may affect wildlife populations in constantly changing ecosystems.

Materials

area—either indoors or outdoors—large enough for students to run; e.g., playing field; chalkboard or flip chart; writing materials

Age: Grades 4—12
Subjects: Science, Math, Social Studies, Physical Education
Skills: application, comparing similarities and differences, description, discussion, generalization, graphing, kinesthetic concept development, observation, psychomotor development
Duration: 30—45 minutes
Group size: 15 and larger recommended
Setting: indoors or outdoors; large area for running needed
Conceptual Framework Reference: I.C.2., III.B., III.B.2., III.B.3., III.B.5., III.C., III.C.1., III.C.2., III.E., III.E.1., III.E.2., III.F., III.F.1., III.F.2., III.F.3., III.F.4., III.F.5., IV.C., IV.C.1., IV.C.2.
Key Vocabulary: habitat, limiting factors, predator, prey, population, balance of nature, ecosystem



Procedure

1. Begin by telling students that they are about to participate in an activity that emphasizes the most essential things that animals need in order to survive. Review the essential components of habitat with the students: food, water, shelter, and space in a suitable arrangement. This activity emphasizes three of those habitat components—food, water, and shelter—but the students should not forget the importance of the animals having sufficient space in which to live, and that all the components have to be in a suitable arrangement or the animals will die.

2. Ask your students to count off in four's. Have all the one's go to one area; all two's, three's, and four's go together to another area. Mark two parallel lines on the ground or floor ten to 20 yards apart. Have the one's line up behind one line; the rest of the students line up behind the other line.

3. The one's become "deer." All deer need good habitat in order to survive. Ask the students what the essential components of habitat are again: **food**, **water**, **shelter**, and **space in a suitable arrangement.** For the purposes of this activity, we will assume that the deer have enough space in which to live. We are emphasizing food, water, and shelter. The deer (the one's) need to find food, water, and shelter in order to survive. When a deer is looking for **food**, it should clamp its hands over its stomach. When it is looking for **water**, it puts its hands over its mouth. When it is looking for **shelter**, it holds its hands together over its head. A deer can choose to look for any one of its needs during each round or segment of the activity; **the deer cannot, however, change what it is looking for**; e.g., when it sees what is available, **during that round. It can change again what it is looking for in the next round, if it survives.**

4. The two's, three's, and four's are food, water, and shelter—components of habitat. Each student gets to choose at the beginning of each round which component he or she will be during that round. The students depict which component they are in the same way the deer show what they are looking for; that is, hands on stomach for food, etc.

5. The game starts with all players lined up on their respective lines (deer on one side; habitat components on the other side)—and **with their backs to the students at the other line.**

6. The facilitator or teacher begins the first round by asking all of the students to make their signs—each deer deciding what it is looking for, each habitat component deciding what it is. Give the students a few moments to get their hands in place—over stomachs, mouths, or over their heads. (As you look at the two lines of students, you will normally see a lot of variety—with some students water, some food, some shelter. As the game proceeds, sometimes the students confer with each other and all make the same sign. That's okay, although don't encourage it. For example, all the students in habitat might decide to be shelter. That could represent a drought year with no available food or water.)

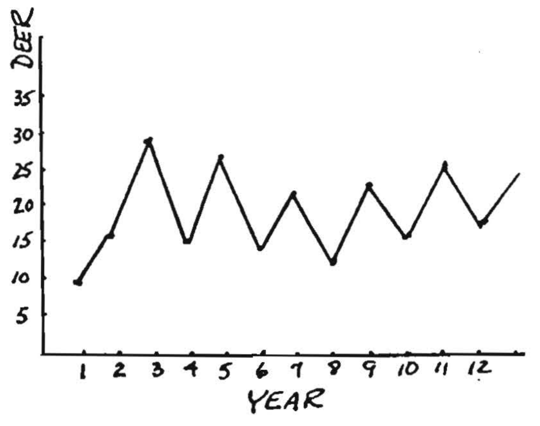
7. When you can see that the students are ready, count: "One. . . two. . . three." At the count of three, each deer and each habitat component turn to face the opposite group, continuing to hold their signs clearly.

8. When deer see the habitat component they need, they are to run to it. Each deer must hold the sign of what it is looking for until getting to the habitat component person with the same sign. Each deer that reaches its necessary habitat component takes the "food," "water," or "shelter" back to the deer side of the line. This is to represent the deer's successfully meeting its needs, and successfully reproducing as a result. Any deer that fails to find its food, water, or shelter dies and becomes part of the habitat. That is, in the next round, the deer that died is a habitat component and so is available as food, water, or shelter to the deer who are still alive. NOTE: When more than one deer reaches a habitat component, the student who gets there first survives. Habitat components stay in place on their line until a deer needs them. If no deer needs a particular habitat component during a round, the habitat component just stays where it is in the habitat. The habitat person can, however, change which component it is from round to round.

9. You as the facilitator or teacher keep track of how many deer there are at the beginning of the game, and at the end of each round you record the number of deer also. Continue the game for approximately 15 rounds. Keep the pace brisk, and the students will thoroughly enjoy it.

10. At the end of the 15 rounds, gather the students together to discuss the activity. Encourage them to talk about what they experienced and saw. For example, they saw a small herd of deer (seven students in a class size of 28) begin by finding more than enough of its habitat needs. The population of deer expanded over two to three rounds of the game, until the habitat was depleted and there was not sufficient food, water, and shelter for all the members of the herd. At that point, deer starved or died of thirst or lack of shelter, and they returned as part of the habitat. Such things happen in nature also.

11. Using a flip chart pad or an available chalkboard, post the data recorded during the game. The number of deer at the beginning of the game and at the end of each round represent the number of deer in a series of years. That is, the beginning of the game is year one; each round is an additional year. Deer can be posted by five's for convenience. For example:



The students will see this visual reminder of what they experienced during the game: the deer population fluctuated over a period of years. This is a natural process, as long as the factors which limit the population do not become excessive, to the point where the animals cannot successfully reproduce. The wildlife populations will tend to peak, decline, and rebuild, peak, decline, and rebuild—as long as there is good habitat and sufficient numbers of animals to successfully reproduce.

12. In discussion, ask the students to summarize some of the things they have learned from this activity. What do animals need to survive? What are some of the "limiting factors" that affect their survival? Are wildlife populations static, or do they tend to fluctuate, as part of an overall "balance of nature?" Is nature ever really in "balance," or are ecological systems involved in a process of constant change?

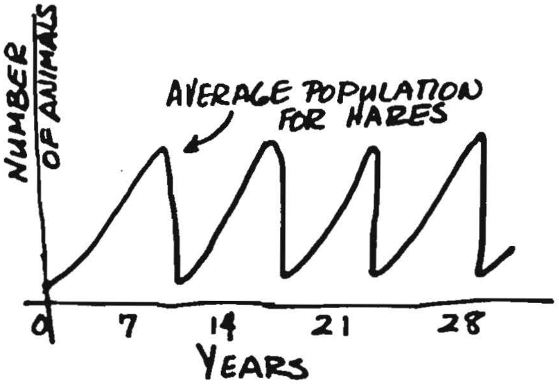
Extensions

1. When you have finished tabulating the graph data and discussing it, ask the students if they

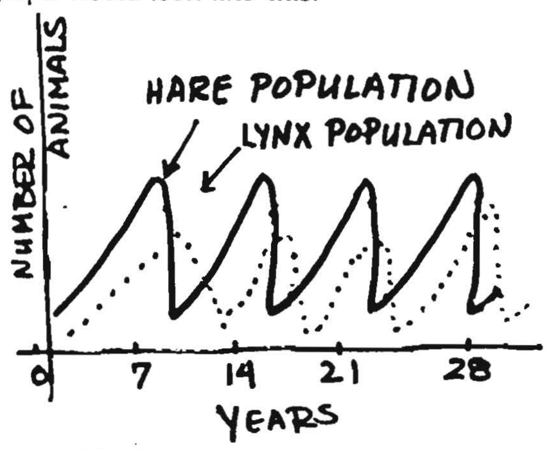
have ever heard of the Hudson Bay trappers in American history. Tell them, briefly, who they were.

There is a hundred years, or more, of records of the activities of these trappers. In those records are some interesting data. These data refer to pelts shipped from America to Europe, particularly the pelts of snowshoe hares and lynx.

Researchers have found that snowshoe hare populations seem to peak about every seven to nine years and then crash, repeating the process over each comparable time period. So, a snowshoe hare population graph would look like this:



It has also been discovered that lynx populations do the same thing—except that they do it one year behind the hare populations. The combined graph would look like this:



Graph this right over the deer graph that you made, adding first the hares, and then the lynx. Ask the students:

- Which animal is the predator? Which prey?
- Are predators controlling the prey, or are prey controlling the predators? (We have been brought up to "know" that predators control the prey—and are now discovering that this is not so. The number of prey animals available tells us how many predators can live in the area.)
- Is this like the deer habitat game we just played? Who controls? (Sometimes the habitat—when the deer population is not too large; sometimes the habitat—when the deer population "gets on top of it" and destroys the vegetative food and cover.)

2. Some recent research has added a new dimension to the story of the snowshoe hares and the lynx.

It has been found that a major winter food of the hare is a small willow. As hare populations grow, the use of the willow plants grows too. But, when the willow plant has been "hedged" or eaten back so far, the plant generates a toxin (poison) which precludes use by the hare. That is when the hare population crashes, followed by the crash of the lynx population about a year later. Then the willow, relieved of pressure, begins to grow again. The hare population begins to grow in response, and last of all, within a year or so, the lynx population follows. And the cycle has begun again—over and over—every seven to nine years.

Discuss the "balance of nature." Is it ever in "balance?"

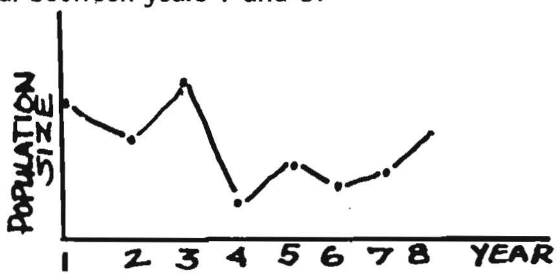
Evaluation

Name three essential components of habitat.

Define "limiting factors." Give three examples.

Examine the graph. What factors may have caused the following population changes:

a. between years 1 and 2?
b. between years 3 and 4?
c. between years 5 and 6?
d. between years 7 and 8?



Which of the following graphs represents the more typically balanced population?

PLEASE
DON'T FEED THE DEER

The white-tailed deer herds at Sharon Woods, Blacklick Woods, Highbanks, and the other Metro Parks are a spectacular sight. Thousands of people are thrilled to see these magnificent animals. For many, these are the first deer they have seen in the wild. This is one of the primary purposes of the Metro Parks–preserving various stages of natural habitat to support the wildlife species that belong there.

In some of the Metro Parks we no longer have small herds of wild deer in balance with their natural habitat. Sharon Woods in particular has an abnormally large herd of deer. As the Metro Parks are becoming increasingly surrounded by developments, and as the deer are coming in contact with more and more people, some are losing their natural fear of man and becoming semi-tame.

Whitetails are grazing animals in spring and summer, feeding on grasses, herbaceous plants, and tender tree leaves. After a brief period of gorging on the fruits, nuts, and grains of nature's fall harvest, deer commence browsing. In late fall and winter they feed on woody buds, twigs, and bark, plus whatever green plants they can find. The Metro Parks still have plenty of natural food for the deer, although at Sharon Woods the tender spring wildflowers and some of the coniferous trees are suffering damage from overgrazing and overbrowsing.

Feeding deer foods that are not part of their natural diet is potentially dangerous to the deer, as some foods cause digestive and other health problems. Feeding them their natural foods is unwise, too, as it makes the deer more used to and dependent on man.

Deer are large, unpredictable, wild animals. If they become accustomed to being hand fed, they will lose their natural shyness and may become aggressive. People attempting to hand feed deer may have their fingers bitten and they may even be knocked down by deer eagerly rushing after choice food.

Metro Parks deer are not permanent inhabitants of any park, but move freely in and out, often traveling considerable distances from the protected park areas. As the deer become less afraid of people, they are in greater danger outside of the park lands–more likely to be struck by cars, to walk up to hunters, and to damage gardens and landscape plantings (thus making more enemies).

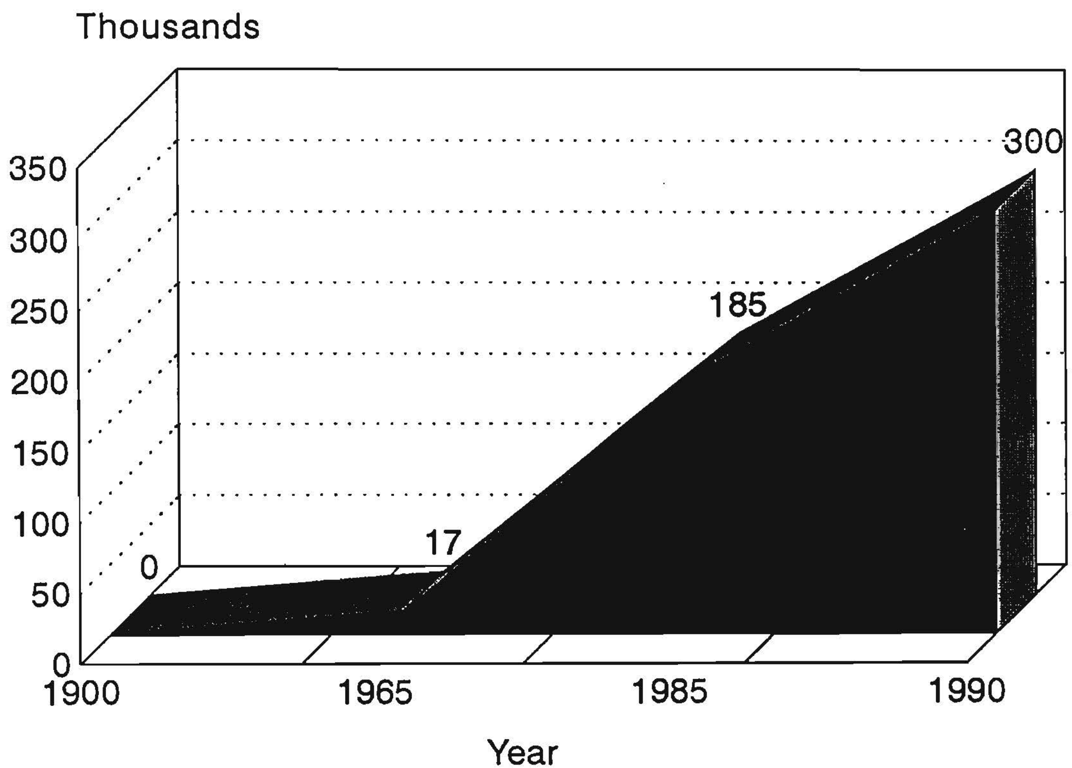
Please help to keep white-tailed deer a part of the wild heritage of the Metro Parks. Observe and enjoy them as wild animals. Don't feed them or attempt to make them tame. Sufficient natural food is available for them in the parks. As these deer become more accustomed to people, the problems will mount for all involved–especially the deer.

Additional Safety Concerns

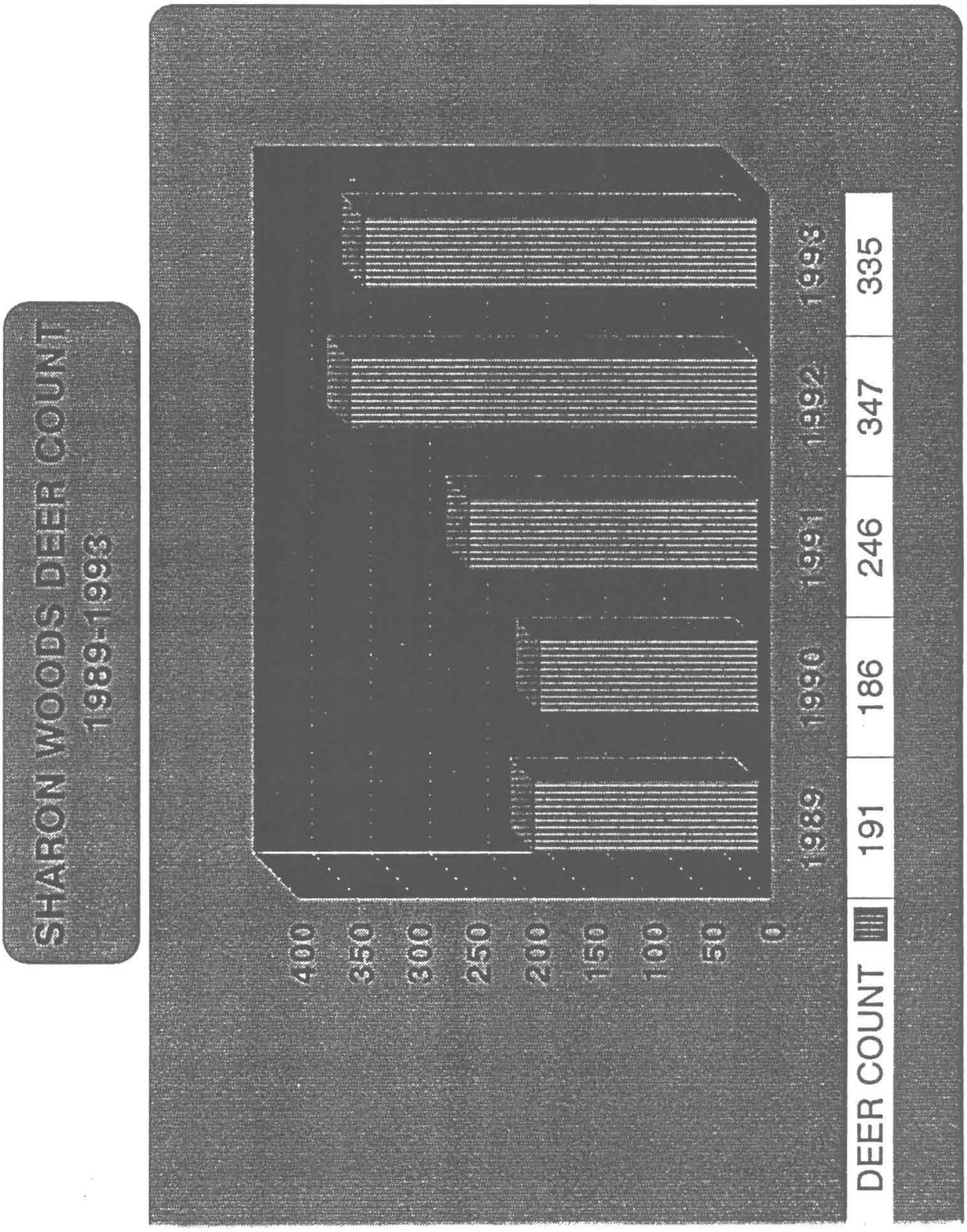
Park roads are governed by traffic regulations which include NO STOPPING. Deer can be observed from several parking areas. Stopping along a roadway for any purpose other than an emergency is dangerous and forbidden.

Enjoy the deer in your Metro Parks while remembering the safety regulations for visitors and for wildlife.

Deer Population Increases Within Ohio



deer 17


SHARON WOODS DEER COUNT
1989-1993
400
350
300
250
200
150
100
50
0
1989
1990
1991
1992
1993
DEER COUNT
191
186
246
347
335

THE SHARON WOODS DEER PROBLEM

INTRODUCTION: Sharon Woods Metropark is located in northern Franklin County. For the past decade, netroparks officials have been closely monitoring the white-tailed deer herds in Sharon Woods and other metroparks. The white-tailed deer herd at Sharon Woods has now achieved a density of 0.75 deer per acre, or 500 deer per square mile. Wildlife biologists have ascertained that the optimal carrying capacity of Sharon Woods is probably much closer to 30 deer per square mile. Although Sharon Woods once provided prime white-tailed deer habitat, encroaching human populations and changing land-use management practices within the vicinity of Sharon Woods have eroded the deer-supporting qualities of the park. Sharon Woods no longer provides the deer herd access to the successional stages of plant growth and adjacent agricultural lands that many rural Ohio settings provide. Metroparks officials have become increasingly concerned during the past two years with finding an acceptable solution to controlling the white-tailed deer population within the prctected areas of the metroparks. The metroparks biologists have conducted numerous public educational programs for several years and have actively-sought public input regarding the control of the white-tailed deer herd through September 1, 1992. The metroparks officials are now leaning in favor of lethal means to attempt to curb the size of the white-tailed deer herd at Sharon Woods. This choice of population control methods has generated public opposition on moral and ethical grounds involving cruelty to animals and animal rights.

YOUR TASK: You will undertake the roles of the three main human players in the controversy involving the white-tailed deer in Sharon Woods. During part A, as an Ohio Department of Natural Resources **Wildlife Biologist**, you will gather facts about the biology and ecology of white-tailed deer in North America, gather facts about the ecology of Sharon Woods, and gather facts about the ecology of the Sharon Woods white-tailed deer herd. These facts will then be organized into a pamphlet presenting the pertinent information regarding the Sharon Woods deer problem to metroparks officials and the public. Then, during part B, as a **Community Leader**, you will gather data regarding community support for possible strategies to solve the Sharon Woods deer problem through a survey of other community members. You will then tabulate the data generated from this survey, and make recommendations to metroparks officials. Finally, during part C, as a **Metroparks Official**, you will xamine all of the data presented by the wildlife biologist and community leader to choose a strategy which will not only solve the overpopulation problem of the white-tailed deer in Sharon Woods, but also appease as many factions within the community as possible. You will then develop a plan to implement your strategy successfully.

YOUR RESOURCES & MATERIALS: To begin this endeavor, you will need to take good notes during our discussions regarding the Sharon Woods deer problem. You will need to refer to these notes, and to the other notes and activities we have completed during Unit A.

You will also be provided with two folders containing 56 pieces of information. These informational items will provide a wide range of viewpoints and opinions from a variety of sources. This folder **will not leave the classroom**, and will be **returned to the teacher** at the end of each class period. You will not make any marks or remove any items from the folder overnight. You may, however, bring change and **photocopy** any of the items from the folder if you would like a personal copy. This may be done in the school library.

You will probably also need to make use of classroom textbooks and periodicals, and literature found in the school and public libraries. We will have one class period to attend the library and locate resources. Other research time in the libraries will be during your own time. An additional resource could include phone conversations with the actual persons involved with solving the Sharon Woods deer problem. Several important contact persons and their phone numbers are:

ODNR Wildlife Biologist - Dave Graham (614) 265-6300
U.S. Humane Society Official - Allen T. Rutberg, Ph.D. (202) 452-1100.
Metroparks Official - Roger Hubble, Director (614) 891-0700.

A visit to Sharon Woods Metropark to observe the nature of the problem in person would also be a good idea. There are many types of educational programs still being offered to the public. You could attend one of these sessions, or go to the park on your own. Sharon Woods Metropark's phone number is. (614) 891-0700.

IMELINE: You will have this week to complete this assignment. You will have time every day in the classroom, but you will also need to make good use of homework time as well to complete this assignment with a high-quality grade in mind.

DIRECTIONS: To complete work on part A, answer all questions completely, fill in the tables when asked to do so, and plot all graphs. You will need to refer to the 56 informational items in folders A and B to complete some of this work. To complete work on part B, conduct a survey of your parents and family as well as the parents of you friends. You will need to survey at least ten adults. Then you will need to interpret and analyze your results when asked to do so. You will need to refer to the 56 informational items in folders A and B to complete some of this work. To complete work on part C, you will need to analyze all of the informational items in folders A and B and in the work done for parts A and B. Write your essays in a concise and complete manner. All of your written work needs to be complete and written neatly. If your writing is unreadable, your answer is obviously incorrect. Good luck in this endeavor!

TABLE 1: Ohio & Sharon Woods Deer Statistics

Year	Number of Ohio Deer	Number of SW Deer	Number of SW Auto/Deer Accidents	Deer Density of SW	Plant Diversity of SW	Vertebrate Diversity of SW
1900	0				350	25
1910	350				400	25
1920	500				450	25
1930	8000				500	25
1940	11000				500	25
1950	12000				500	25
1960	13000	3			500	25
1970	30000	30			500	25
1980	90000	50			500	25
1981	110000	60			475	23
1982	170000	75			440	22
1983	230000	95			410	22
1984	280000	120			360	21
1985	290000	150			290	18
1986	300000	170	8		220	17
1987	310000	180	22		150	14
1988	320000	190	34		100	12
1989	340000	200	42		60	9
1990	370000	220	40		45	8
1991	390000	250	53		40	7
1992	450000	350	**29		40	7
*1993	>500000	>550	>79		<38	<6

* predicted values with no cull during winter 1992-1993.
**partial year to date (September 30, 1992).

TABLE 2: Ohio Deer Statistics

Age	Average Weight	Reproductive Rate/Year
1	100	1
2	160	2
3	200	2
4	220	2
*5	235	3
6	260	3
7	280	3
8	300	3

*fewer than five percent reach this age.

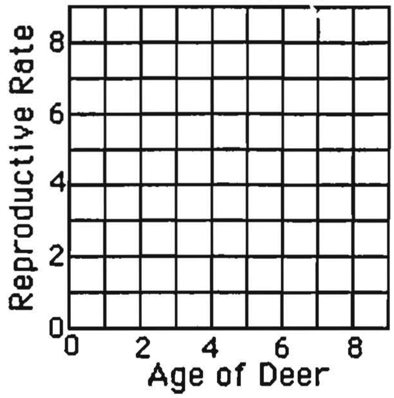
PART A - ODNR REPORT TO COLUMBUS AND FRANKLIN COUNTY METROPARKS OFFICIALS

WHITE-TAILED DEER IN OHIO AND SHARON WOODS METROPARK

RESEARCHER NAME:________________________________ **DATE SUBMITTED:**________________

1. The size of Sharon Woods Metropark in acres:
2. The size of Sharon Woods Metropark in square miles:
3. Fill in the data table column for Sharon Woods Metropark Deer Density in number of deer per square mile.
4. Calculate the fertility of white-tailed deer by creating the fertility graph below.

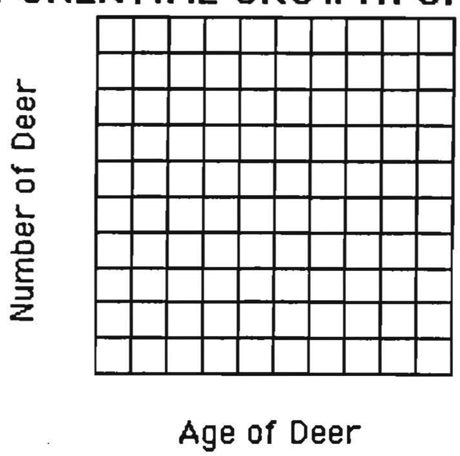
FERTILITY



5. If you start with two pairs of white-tailed deer, 2 males and 2 females, aged six months:
   Construct the data table below for exponential growth of deer.
   Pay attention to the number of offspring a deer can bear at each age.
   Pay attention to the number of deer present in each age group.
   Assume that 50% of the offspring are females, and that none of the offspring perish.

6. Using the data table, calculate the exponential growth of deer by creating the graph below.

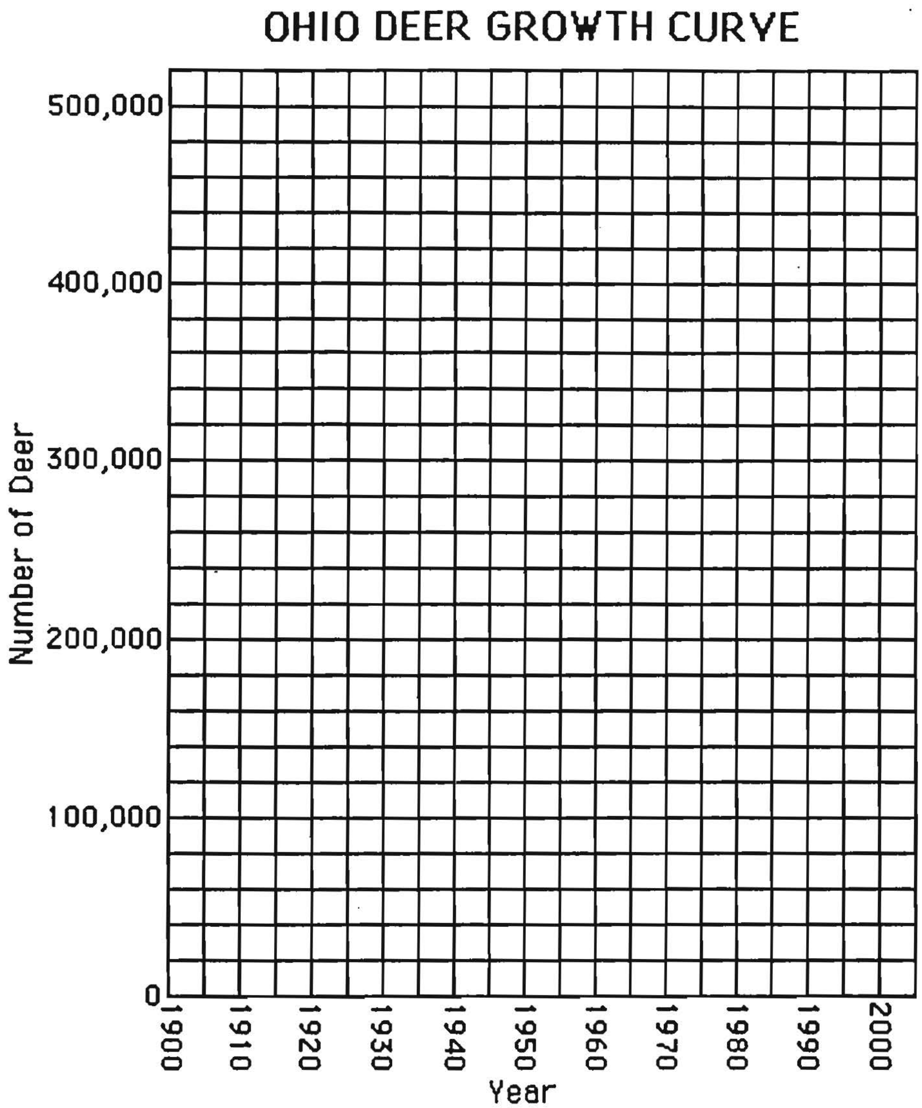
EXPONENTIAL GROWTH OF DEER



7. Why does this exponential growth occur for Ohio deer?

	Adult Deer			Offspring Deer			
Year	No. Females	No. Males	Total	No. Females	No. Males	Total	Grand Total
1							
2							
3							
4							
5							
6							
7							
8							

8. Calculate the Ohio deer growth curve by creating the graph below.
9. Continue the trends of the graph and predict future numbers of Ohio deer.



10. What are the controls or limiting factors affecting Ohio's deer population?

11. What is the carrying capacity of southeastern Ohio in the number of deer per square mile?

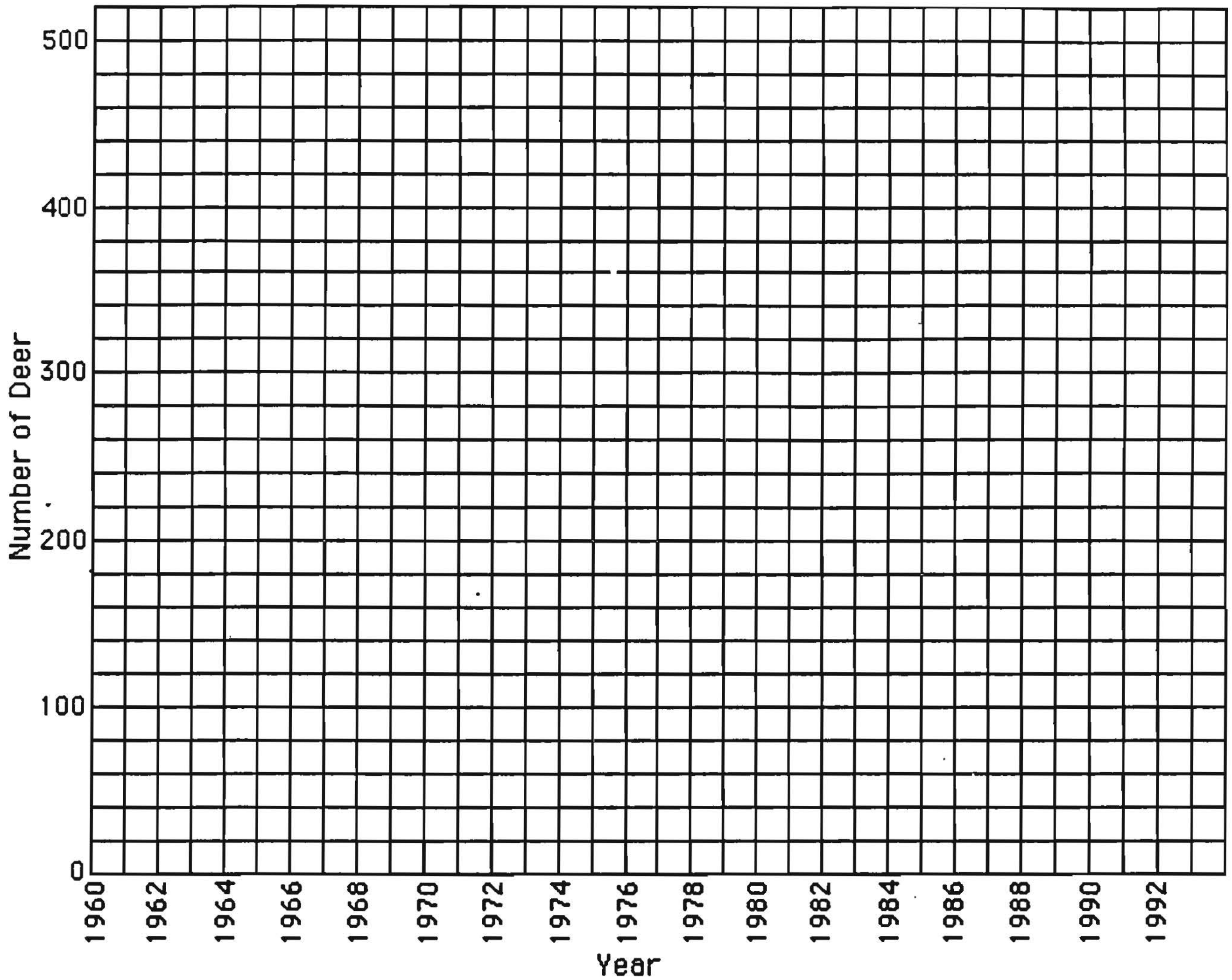
12. What are the ecological conditions of prime southeastern Ohio lands for deer growth?

13. What is the carrying capacity of Sharon Woods Metropark in the number of deer per square mile?

14. What ecological conditions make Sharon Woods carrying capacity lower than southeastern Ohio?

15. Calculate Sharon Woods deer growth curve by creating the graph below.
16. Continue to make the graph showing a prediction for the future.

SHARON WOODS DEER GROWTH CURVE



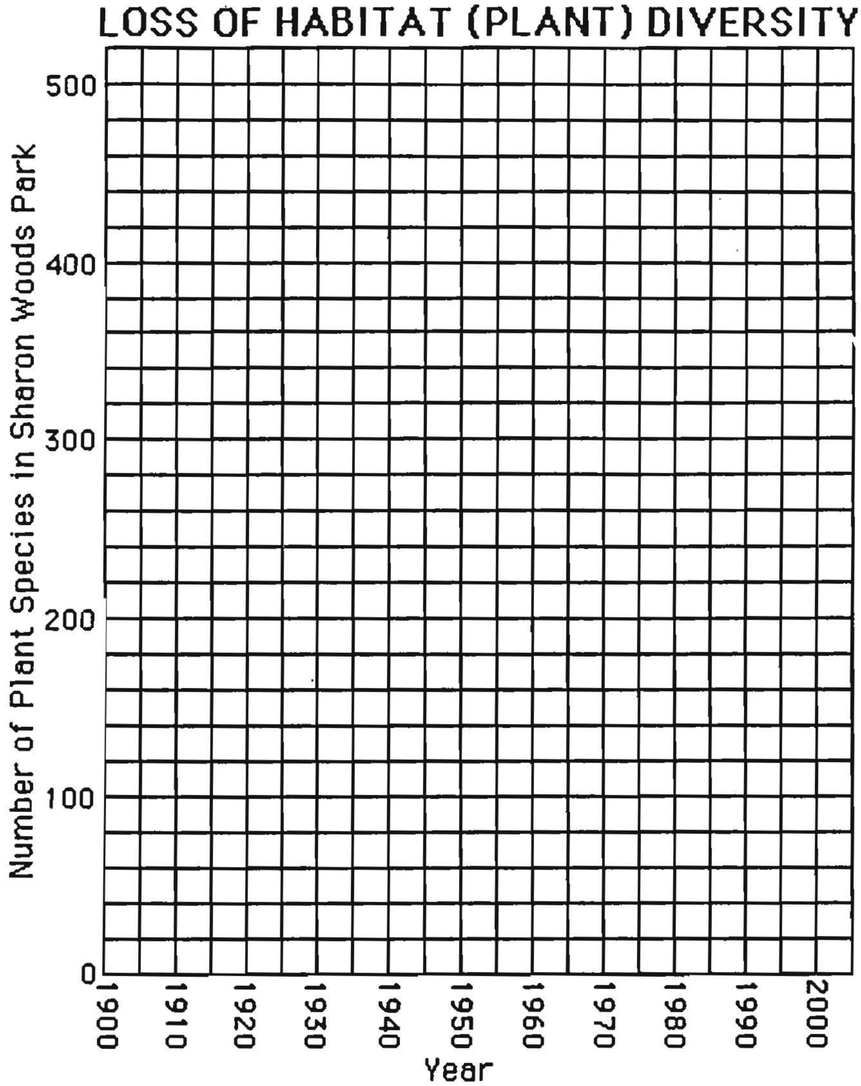
17. Why has deer growth become accelerated in Sharon Woods Metropark?

18. What are the factors limiting this growth?

19. How has poor planning contributed to this problem?

20. What new problems are occuring today or may occur in the future because of the deer?

21. Calculate the loss of plant diversity in Sharon Woods by creating the graph below.
22. Continue the graph to predict future trends.

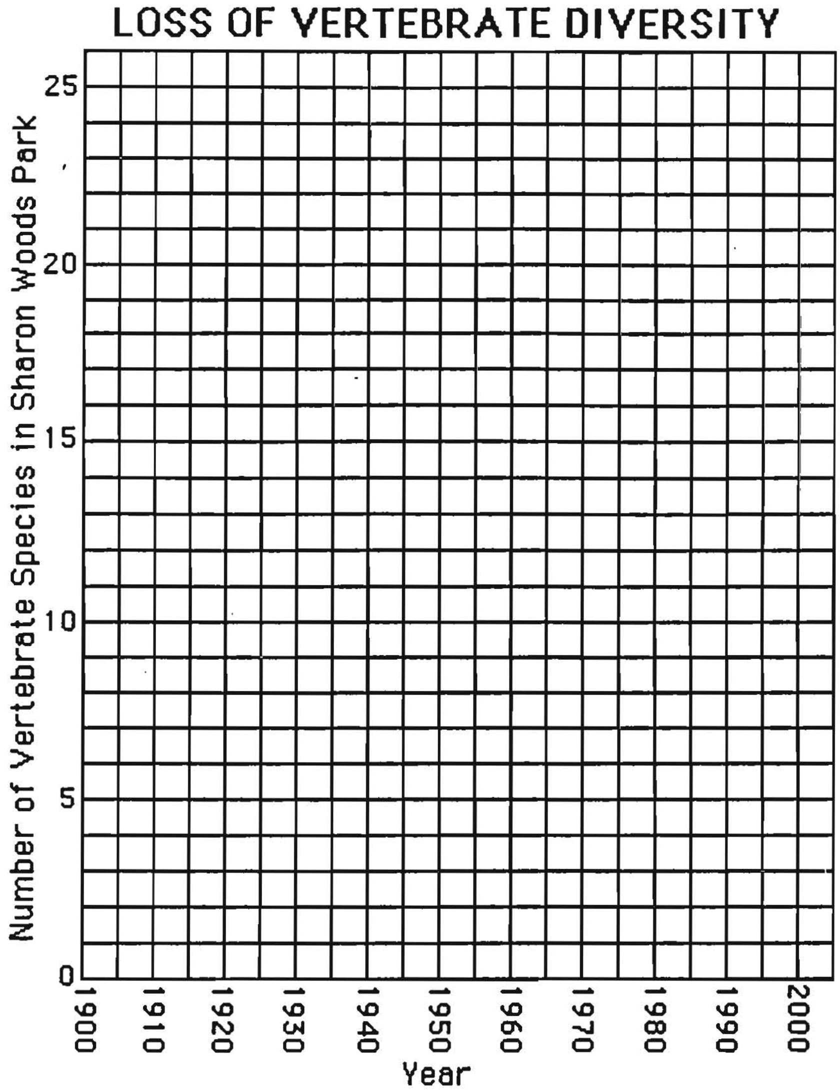


23. What has caused these problems?

24. What are some plants which the deer have not eaten?

25. How can the loss of plant diversity affect the ecosystem?

26. Calculate the loss of vertebrate diversity with Sharon Woods by creating the graph below.
27. Continue the graph to predict future trends.



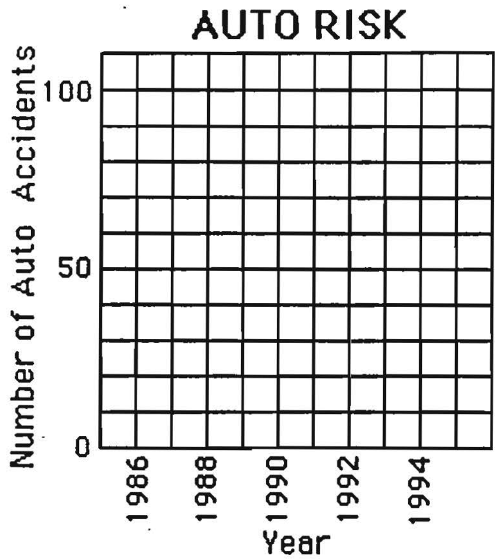
28. Why has this decline occured?

29. What species have actually increased in number or been aided by the deer?

30. Which species are in the greatest danger of extinction?

31. What will happen to vertebrate species if the number of deer begins to decline?

32. Calculate the risk to automobiles be filling in the graph below. Predict future trends as well.



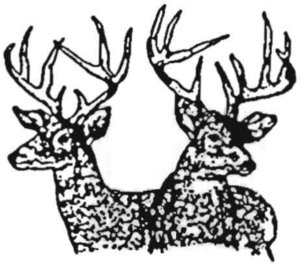
33. Why do deer leave Sharon Woods park?

34. Why was this not a problem which occured in the past?

35. What other problems do residents living near Sharon Woods experience because of the deer?

36. At what point might ecological collapse occur? How many deer? Why has it not collapsed yet? What might happen after the collapse? Provide reasons for each of your answers.

Deer Management



Robert J. Stoll, Jr., and Robert W. Donohoe
Waterloo Wildlife Experiment Station, New Marshfield, Ohio 45766
Patrick M. Ruble
Wildlife Management and Research, Fountain Square, Columbus, Ohio 43224

The white-tailed deer is Ohio's only big game animal. Beginning with an invasion from neighboring states in the early 1930s, Ohio's modern-day deer herd has grown considerably. In 1965 there were an estimated 17,000 deer in the state, by 1970 over 30,000, and by 1985 more than 150,000. Three factors made the return of deer possible. First was the improvement in range conditions, which occurred primarily as a result of farm abandonment in eastern and southern Ohio. Second was the implementation of harvest management by deer zone and county, based on biological principles. The third factor was effective game laws and law enforcement. An upsurge in hunter interest and participation has paralleled the increase in deer. Licensed deer hunter numbers have swelled from 13,000 in 1965 to over 284,000 in 1986.

Although nearly everyone relishes the presence of the watchful whitetail, when deer become abundant they also become controversial. Deer may be viewed as a superb game trophy by the sportsman, a prized addition to the landscape by the nature lover, a threat to crops by the forester and farmer, and a road hazard by the motorist. Agricultural crop damage by deer and deer-vehicle collisions highlight the deer-people conflict; they also intensify the complexity of deer management. The high quality of Ohio's deer range, and the absence of any natural predators of deer, dictate harvest management as the best way of maintaining deer populations at appropriate levels. These "appropriate levels" are often subject to dispute because they must be a compromise between those who want more deer and those who want fewer.

The Management Strategy

The Division of Wildlife is charged with responsibility for managing the deer resource. Our deer management objective is to provide a deer population that will allow maximum recreational opportunity while minimizing conflicts between agriculture, motor travel, and other areas of human endeavor. To accomplish this objective, we gather and analyze information relating to the deer resource and to public desires associated with the deer resource. From this we determine appropriate deer population levels, and develop and refine harvest regulations to meet those population goals. This is a familiar strategy, one commonly used by managers in many areas of endeavor. At this point the similarity ends, because deer present management challenges that are unique: In the next few paragraphs we will identify some of these challenges and explain the management solutions.

Inventorying Deer

Counting deer is one of the most difficult tasks in the management process. Their secretiveness and mobility—which varies seasonally and with deer age and sex—makes precise population estimates impossible. As a result, we have to use a variety of methods to estimate deer populations. Harvest results from statewide compulsory checking stations, deer highway accident records, and snow track and aerial censuses in selected areas are used annually to determine deer population status. We also monitor the physical and reproductive condition of the deer herd. We determine these population estimates and trend indicators for each county.

Optimum Population Levels

After the deer population has been inventoried, the next step in the management process is to determine the best level at which to maintain it. Because of the vastly different desires of people associated with deer, this too is a difficult task. Differences among Ohio counties in the amount and quality of deer range, intensity of agriculture, amount of highway traffic, density of human population, and other factors make it desirable to manage deer on a county basis.

In the past, the Division determined desirable herd levels by analysis of deer-vehicle collision records, landowner complaints of agricultural crop and property damage, surveys of hunting pressure and hunter success, and comments at public meetings. This information was examined in relation to deer inventory data and deer density goals for each county.

However, because of continued conflicting views as to appropriate herd size, recently we have sought more direct input from Ohio's citizens. This input is provided through surveys of rural landowners. We conducted the most recent survey about five months before the 1985 hunting season, when Ohio's deer herd was at a modern-day high. We sent 7,647 questionnaires and received 5,190 (68%) usable returns. All of Ohio's 88 counties were represented except Cuyahoga, which has comparatively few rural landowners.

The key question on the survey was whether the deer herd should be increased, kept the same, or decreased in the landowner's area. Almost 77% of the respondents indicated that they would like to see the herd size remain the same or increase. It should be kept in mind that these were rural landowners responding at a time when the deer herd was probably as high as it had ever been. If urban residents had been included in appropriate proportions, this percentage no doubt would have been significantly higher.

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Although many rural landowners wanted the deer population the same or higher, some were suffering significant crop damage and felt that the population was too high. Therefore, we grouped rural landowners who said that they were farmers; farmers made up 80% of the rural landowners. Their response was then compared with the estimated deer population in their county. By doing this, we derived a farmer-preferred deer density level at which about 40% of the farmers surveyed felt the herd should remain the same, 30% felt it should be decreased, and 30% felt it should be increased. In this fashion we established an optimum deer density level based on farmer preferences for each county in the state.

We recognized that in about 24 counties the optimum deer density preferred by farmers was too high and would result in critically high deer-vehicle accident rates. This situation was most common in the highly urbanized counties of northeast and southwest Ohio. Thus, in these 24 counties we derived the optimum deer density level from deer-vehicle accidents rather than farmer preferences.

In summary, we determine optimum population levels for each county based on landowner attitudes and deer-vehicle accident rates. We believe that management using these population levels as a guideline currently provides the best and most objective basis for meeting the Division's deer management goal of furnishing maximum recreation and minimum conflicts with agriculture and motorists on a county basis. Farmer preferences and deer-vehicle accidents are the principal inputs used to define appropriate deer densities, because they represent the areas most negatively impacted by deer.

But how does this optimum density level affect Ohio's deer herd, and the deer hunter, farmer, motorist, and general citizen? The county-by-county analysis for the 1986 deer season indicated that the herd was above the optimum level in only about 20 of Ohio's 88 counties. Not surprisingly, almost all of these counties are in east-central and southeast Ohio, the best deer range. In a few of these counties, substantial herd reductions will be required to bring deer populations down to optimum levels. In counties that are below optimum levels, herd increases will partly offset the anticipated decreases in the high density counties.

Because the 20 counties that will be most affected contain the highest deer densities, they also support a disproportionate number of hunters. Initially, hunting success will be high in order to reduce populations. But eventually hunting and deer hunters in those counties will be adversely affected. Hunting will still be good, it just won't be as good. This population reduction will decrease crop damage and vehicle collisions. Ohio's annual deer roadkill is about 12,000—high, perhaps, but not nearly as high as Michigan's 25,000 and Pennsylvania's 30,000.

Harvest Regulations

Currently, the firearm harvest is an effective means of regulating herd levels. Although the state is divided into three deer hunting zones, the herd is managed on a county basis. This is done through three basic types of gun season regulations: (1) the "buck only" regulation allows for maximum herd growth in counties well below optimum density; (2) the "antlerless permit" regulation provides for a controlled harvest of females in counties approaching or at optimum levels; and (3) the "either sex" regulation allows for a liberal harvest of females in counties exceeding optimum levels or where antlerless permits have been ineffective in controlling herd growth. Population levels are controlled by regulating the harvest of females.

The effectiveness of this system will vary somewhat from year to year, depending primarily on the accuracy of population estimates, the demand for antlerless permits, and the weather during the firearms season. An overharvest or an underharvest in a particular county can be compensated for by increasing or decreasing the number of antlerless permits the following year or by shifting counties back and forth between either-sex and antlerless-permit seasons. We hope that over the long-term, the number of deer in the state (and in every county) can be maintained at approximately the desired level with this harvest management system.

The deer hunter provides important input into the management of Ohio's deer seasons. In addition to receiving voluntary comments in the mail and at meetings, we poll a representative sample of deer hunters about once every five years. Hunters from every Ohio county are included in the survey, which usually exceeds 5,000 licensed deer hunters. The survey provides information on hunter opinions and attitudes on topics like season length, legal hunting weapons, bag limit, hunting pressure, and deer population levels. Where appropriate, we incorporate this information into the deer management process. These surveys are particularly important to the management process because, unlike voluntary comments which may be biased toward special interests, they provide a more representative view of hunter opinions and concerns.

Special Management Techniques

By managing for optimum deer densities on a county basis, we expect to prevent or eliminate widespread agricultural problems with deer. However, some localized crop damage is still likely to occur. Even with a county population at the desired level, deer will move to and concentrate in areas of good habitat. Farm fields—and particularly orchards—close to good deer habitat are likely to sustain damage. The "kitchen" is just too close to the deer's "living room."

We have developed special programs to help landowners in such situations. One program offers technical advice on deer repellents and deer proof fencing. In another program, we issue special damage permits to the landowner for antlerless animals; these permits allow hunters, during the regular shotgun season, to take antlerless deer on the lands where damage is occurring and on adjoining lands of cooperating neighbors. Still another program allows farmers or landowners experiencing deer damage to shoot nuisance deer out of season. Additional information about these programs can be obtained from the local State Game Protector or by writing: Division of Wildlife, Wildlife Management and Research, Fountain Square, Building C-4, Columbus, Ohio 43224.

Managing Ohio's Deer Herd: The Art and Science

by Mike Tonkovich

The return of the white-tailed deer to Ohio is a wildlife success story unparalleled in the history of the Buckeye State. In 1996, for example, Ohio's deer harvest in a total of just four counties was higher than the estimated 17,000 deer in the entire state in 1965. The following is the story of deer management in Ohio—then and now.

The story of Ohio's deer herd is similar for nearly all states east of the Mississippi. Those forces that extirpated deer from Ohio by 1904 were at work in other states across much of the species' range. While figures vary, there were an estimated 20 to 40 million whitetails inhabiting the United States prior to European settlement. However, extensive conversion of forests to farmland and unregulated shooting greatly reduced deer numbers. The whitetail was absent from the Buckeye State for 20 years in the early part of this century. Their phenomenal return was made possible by reversing and/or eliminating the same factors that originally led to their demise.

While deer have returned, those factors that once regulated their populations (natural predators, market hunting, and possibly wildfires) are gone or greatly reduced. What remains, however, is the fact that the size of Ohio's deer herd still represents a compromise between those people who want more deer and those who want less. Finding that balance is what the Division of Wildlife is charged with by state law: deer management.

Ohio's Deer Management Goal: [A deer population that will allow] ". . . maximum recreational opportunity while minimizing conflicts with agriculture, motor travel, and other areas of human activity."

Since at least the late 1950s, the goal of Ohio's deer management program has been to provide maximum recreational opportunity while minimizing conflicts with agriculture, motor vehicles, and other areas of human activity. In practice, this means establishing a population objective or target level of deer for each county. County deer target levels are based on farmer survey data, except in urban counties where they are based on deer-vehicle accidents. Each year, the status of the herd relative to this target is evaluated. Based on this evaluation, a harvest objective is established for each county and harvest regulations needed to achieve that objective are then implemented.

County deer target levels taken from opinion surveys of Ohio's farmers are updated about every five years. Among other things, respondents are asked if they would like to see the size of the deer population change and if so by what percentage. An average percent change is computed for each survey region and then applied to the deer herd estimate to arrive at a target level. These surveys also provide a profile of the farming communities' opinions of and experiences with deer. The Division has found that farmers' attitudes toward deer differ little from the general public's.

Results from the 1995 survey indicated that 40 to 50 percent of farmers enjoy seeing and having deer around. About the same number of farmers agreed, but also worried about the problems deer cause. Only five percent of farmers regard deer as a nuisance. Recent research from The Ohio State University revealed that despite annual losses approaching $50 million, of which deer are responsible for half, Ohio's farmers generally believe that the benefits of wildlife outweigh their costs. Thus, while farmers play the largest role in deciding when enough deer are enough, their decision is likely to be one that most Ohioans can live with.

So, how well is Ohio doing? Fall 1997 deer populations are projected to be at target levels in 13 counties, above target levels in 42 counties, and below target levels in 33 counties. While only 13 counties are on target, many counties are only slightly above or below the desired mark. Furthermore, since increasing the size of a deer herd is relatively easy, counties below target are not a primary concern. Of greatest concern are eastern Ohio counties, most of which are in the state's Hill Country. Some of these counties continue to remain well above target level, despite aggressive, focused, and innovative deer harvest regulations.

In nearly every whitetail state, laws exist that mandate that the deer herd be managed

Continued on page 5

Tim Daniel

A rule-of-thumb for landowners to remember is that they need to harvest about [illegible]0 percent of the deer on their property (about three-fourths of these should be antlerless deer) to maintain a stable deer herd. By harvesting anything less than this number of deer, landowners are managing for an increasing deer herd size.

Managing Ohio's Deer Herd. . . Continued from page 4

for the good of the public; Ohio is no exception. But what about the deer themselves, the habitat, and other wildlife species? With long-term condition data now available for Ohio's deer herd, and recent research findings revealing the negative effects that unnaturally high deer populations have on the environment and other species, these issues are playing a much greater role in the management process. A factor that is carefully considered is the physical condition of the herd.

While deer condition in western Ohio remains unchanged since the mid-1970s, deer herd condition (as indicated by measuring the antlers of deer approximately one-year old) appears to be declining in eastern Ohio. Furthermore, a comparison of 1996 deer weights with 1982 data revealed that Hill Country deer weigh significantly less now than in the past. Thus, in addition to exceeding target levels, the deer herd in southeastern Ohio appears to be approaching the limits of the available food supply. This is an inevitable consequence of two simultaneous events: aging of the forests and continued deer herd growth. This autumn's harvest regulations should help to trim the size of the herd in the affected counties. However, regulations alone are not enough.

Successful management of Ohio's deer herd in the future will require a cooperative effort between Ohio's hunters and landowners to eliminate obstacles that currently limit the taking of more deer. One obstacle is a reluctance on the part of hunters to abandon traditional hunting grounds and seek new areas that may be harder to access, but provide higher deer numbers. A second obstacle is a reluctance on the part of landowners to grant access of their lands to deer hunters. Sportsmen and women must work harder to cultivate positive hunter-landowner relationships. Landowners can help by allowing deer hunting on their property and actively recruiting good, ethical deer hunters.

A rule-of-thumb for landowners to remember is that 50 percent of the deer on their property needs to be harvested (about three-fourths of these should be antlerless deer) to maintain a stable deer herd. By harvesting anything less than 50 percent, landowners are managing for an ***increasing*** deer herd size.

Ohio's deer herd is a wildlife population in a state of change. And whether you are a deer hunter, landowner, or simply a wildlife watcher, the Ohio Division of Wildlife is asking for your support in helping us manage this tremendous natural resource, the white-tailed deer—once gone, and now restored.

1996-97 Deer Hunting Season Results

Hunters killed 158,000 deer during the various 1996–97 deer hunting seasons in Ohio. This total represents a 12 percent decrease from the record 1995–96 kill of 179,543 deer, and is the third highest overall. There were 170,527 deer taken during the 1994–95 seasons.

CHECKS AND BALANCES

Objectives
Students will be able to: 1) evaluate hypothetical wildlife management decisions; and 2) identify at least four factors which can affect the size of a wildlife population.

Method
Students become managers of a herd of animals in a paper-and-pencil and discussion-based activity.

Background
Wildlife managers attempt to maintain healthy populations of wild animals, while factors—both avoidable and unavoidable—affect the populations. Some of these factors are loss of habitat, weather conditions, pollution of food and water sources, development of other natural resources, poaching, and recreation pressures. Many people are unaware of how such pressures can affect wildlife.

In the United States, it is the legal responsibility of state wildlife agencies to manage the wildlife populations within their respective states. It is the legal responsibility of the U.S. Fish and Wildlife Service, under the U.S. Department of the Interior, to govern some policies and programs affecting migratory species of animals (principally birds) and threatened or endangered species, as well as illegal importation and expor-

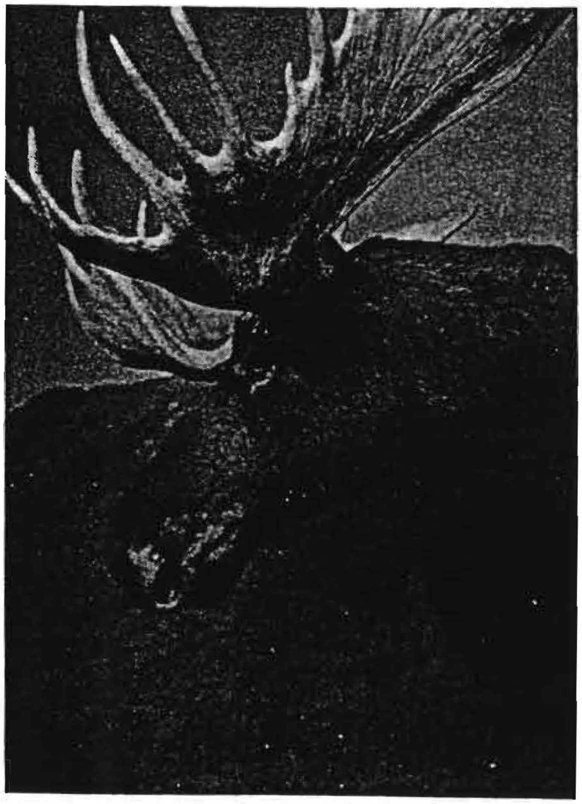
Age: Grades 6-12
Subjects: Mathematics, Science, Vocational Agriculture
Skills: analysis, computation (calculating percentages), evaluation
Duration: one to two 45-minute periods
Group Size: any
Setting: classroom
Conceptual Framework Reference: I.C.3., I.C.4., I.D., III.A.1., III.C., III.C.1., III.C.2., III.E., III.E.1., III.E.2., III.F., IV.A., IV.A.1., IV.A.2., IV.A.3., IV.C., IV.C.1., IV.C.2., IV.C.3., IV.D., IV.D.1., IV.D.2., IV.D.3., IV.D.5., IV.E., IV.E.1., IV.E.4., IV.E.5., IV.E.6., IV.E.7., IV.E.10., IV.E.11., VI.A., VI.A.2., VI.A.3., VI.A.4., VI.B., VI.C., VI.C.12., VI.C.15., VI.C.16., VII.A., VII.B., VII.B.2., VII.B.4., VII.B.7.
Key Vocabulary: management, population, herd

tation of animals and animal products, illegal interstate transportation of all species, with additional responsibilities related to the overall well-being of U.S. wildlife.

Wildlife management is based on the best scientific and technical knowledge available. Such knowledge is growing; however, it is still limited, and is continually affected by changes in the complex relationships between wildlife, human beings, and their shared environments.

In a sense, everyone shares responsibility for wildlife management. Although there are legally responsible agencies, their work requires the thoughtful and informed cooperation of citizens. There are frequently differences of opinion about the most appropriate policies and programs affecting wildlife. Individual citizens, private conservation groups, private industry, community groups, and others all make important contributions to the overall conservation and protection of wildlife and its habitat.

The major purpose of this activity is for students hypothetically to assume the role of wildlife managers, and thus gain insight into some of the complex variables that influence stewardship of wildlife. This activity is not designed to provide a comprehensive understanding of all possible factors which can affect wildlife.



Materials

paper and pencils; paper to make condition cards; dice, one per student

Procedure

1. Each student is asked to be the manager of a moose (or other animal) population. The carrying capacity of the habitat is 100 animals. The point of the activity is to end up with a viable population after nine rounds, simulating nine years. If at any time the student's population reaches less than 10 or more than 200 individual animals, that student no longer has a viable "herd" and watches the other students until the conclusion of the activity.
2. Each student has a beginning population of 100 animals. The cards are separated into three decks of a total of 36 cards: a condition deck (18 cards), a reproduction deck (9 cards), and a management deck (9 cards). Shuffle the cards within each deck. Explain that cards will be drawn in the following sequence: condition card, reproduction card, condition card, management card. This sequence of draw will be repeated, each repetition representing an annual cycle (the students may think of each draw as representing a different season, e.g., autumn, winter, spring, summer). As each card is drawn, it is read aloud to the entire class. Each student then rolls his or her die and follows the instructions on the card to determine his or her herd population's new size. Some computations will result in fractions; numbers may be rounded to the nearest whole. NOTE: Students may object to the use of dice to determine the impact of decisions made for wildlife management purposes. Their concerns are appropriate; wildlife management is based on more than the chance elements reflected in the use of dice. However, chance has its impacts as well, as in the case of weather conditions in a given year. Encourage the students to discuss and consider what is realistic, and what is unrealistic, about the impact of dice in this activity—encouraging the recognition that wildlife management is far more complex than can be represented through this activity.

3. Wrap up the activity with a class discussion. Include topics such as:

- Identify and describe what appeared to be the impacts of the condition, reproduction, and management cards.
- Given one of the objectives of this activity—to evaluate hypothetical management decisions—what seemed to be the benefits and/or liabilities, if any, of management decisions made?
- Did populations "managed" under different strategies by different students show different trends? How do these compare? Would students "manage" differently if given a second chance?
- What aspects of this activity seemed realistic? Which didn't?
- What are examples of ways that habitat can be improved? Short term? Long term?
- Is human management of wildlife populations necessary? Beneficial? Why or why not? For people? For the animals?

Variation

Add a monetary aspect to the activity. Students allowing hunting might have more available revenue for projects like habitat enhancement based on income from sale of hunting licenses. Other expenses might include salaries of wildlife managers, funds for research, feeding animals in severe conditions, relocation, etc.

Evaluation

Name four factors that can affect the size of a wildlife population.

Some wildlife managers have said that wildlife management involves more management of people than of wildlife. Explain what they might mean by the comment.

INSTRUCTIONS FOR MAKING CARDS

Make the following cards, according to three categories: **Reproduction Cards, Condition Cards, Management Cards.** There are 36 cards in total. The number in parentheses indicates how many of each card are to be made. NOTE: The numbers of cards and the suggestions for numerical manipulations, e.g., three times the roll, are relatively arbitrary. They are designed for students to recognize that a number of diverse factors can affect wildlife; the numerical weights should not be interpreted literally.
(After using these cards once, students may want to experiment with making additional cards, or changing these cards. Students may also want to make additional complete sets of cards for use by small groups or individual students.)

NOTE: As the cards are read aloud, be certain to note differences in decreasing or increasing herd size by percentage or by number.

Reproduction Cards

Reproduction Card—Excellent Year (3)
This has been an excellent reproduction year. Increase your herd by (100/your current population size) times five times your roll, if your current population is over 50 individuals. If your population is between 50 and 10, increase your population by the number equal to five times your roll. If your population is under ten, you may not reproduce.

Reproduction Card—Average Year (6)
This has been an average reproduction year. Increase your herd by (100/your current population size) times three times your roll, if your current population is over 50 individuals. If your population is between 50 and 10, increase your population by three times your roll. If your population is under 10, don't reproduce.

Condition Cards

Weather Card (2)
____________(Students need to specify what) has had a serious negative impact on the survival of the herd. Decrease your herd by the percentage equal to five times your roll.

Weather Card (2)
____________(Students need to specify what) has had a dramatic positive impact on the survival of the herd. Increase your herd by the percentage equal to five times your roll.

Habitat Destruction Card (2)
____________(Students needs to specify what) has occurred, destroying critical habitat. Decrease herd size by the number five times your roll.

Predator Card (1)
Predation has occurred, affecting the herd size. Decrease herd size by the percentage equal to your roll.

Habitat Degradation Card (4)
____________(Students need to specify what) has occurred, damaging critical habitat. Decrease herd by the number equal to three times your roll.

Disease Card (1)
Disease has struck the herd. Decrease herd by the percentage equal to your roll.

Habitat Loss Card (5)
____________(Students need to specify what) has resulted in a loss of critical habitat for the herd. Decrease herd by the number equal to five times your roll.

Poaching Card (1)
Poaching—illegal killing of animals—has reduced the size of the herd. Decrease herd by the number equal to two times your roll.

Management Cards

Habitat Restoration Card (1)
____________(Students need to specify what) has occurred, restoring critical habitat. Increase herd by the percentage equal to five times your roll.

Habitat Alteration Card (2)
____________(Students need to specify what) has occurred, altering critical habitat. Increase or decrease (students choose which before rolling the die) herd by the percentage equal to three times your roll.

Habitat Improvement Card (1)
____________(Students need to specify what) has occurred, improving critical habitat. Increase herd by five times your roll.

Research Card (1)
____________(Students need to specify what) research has been successfully accomplished. Increase or decrease (students choose which before rolling the die) herd by two times your roll.

Law Enforcement Card (1)
____________ (Students need to specify what) law enforcement activities have protected the herd against illegal actions like poaching. Increase herd by the percentage equal to two times your roll.

Education Card (1)
____________(Students need to specify what) education activities have led to increased understanding of wildlife and habitat. Increase or decrease (students choose which before rolling the die) herd by the percentage equal to two times your roll, or by two times your roll.

Habitat Acquisition Card (1)
Habitat acquisition has increased the area of available and suitable habitat. Increase herd by five times your roll.

Hunting Card (1)
A request for a hunting season has been made. Do you wish to allow hunting in your area? If yes, decrease your herd by the percentage equal to five times your roll. If no, record no change in the size of your herd.

Hunting and Wildlife Management

Purpose

Because of human intervention with wildlife species and habitats, some species must be actively managed to achieve stable and healthy populations. In this Activity, students develop a management plan to handle deer overpopulation.

Learning Outcomes

After completing this Activity, students will be able to:

A. List three reasons why people manage deer populations.

B. List three strategies that might be used in deer management.

C. Write a one-page report discussing the advantages and disadvantages of various wildlife population management techniques.

Organization

Who: Individual students, and groups of four or five
Where: Indoors
When: Any time of year
Time: Two to three hours

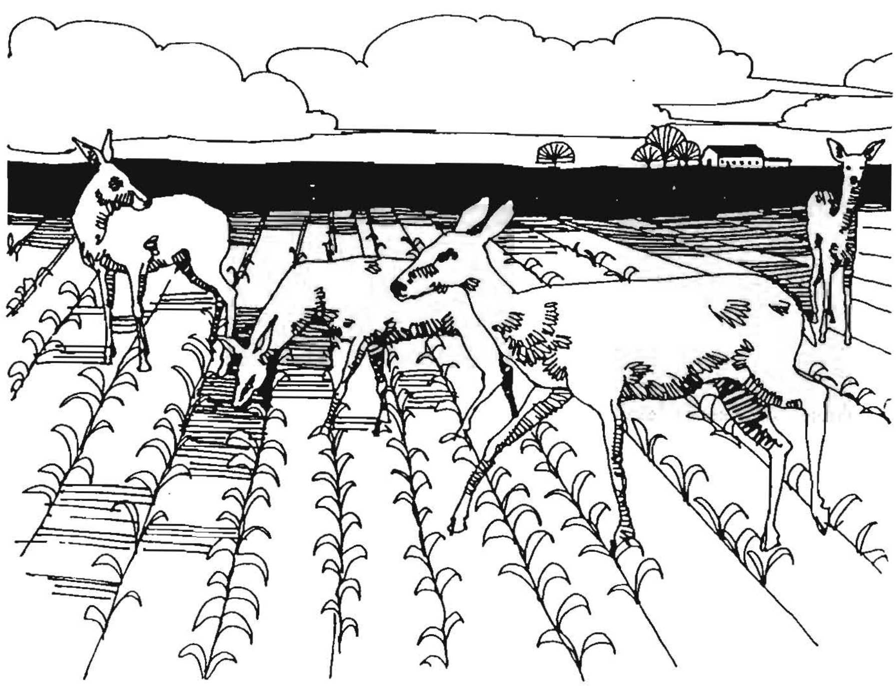
Materials: For Each Student

- Data Sheets
- Pencil
- Paper

Directions

1. In this Activity, students will be asked to design a one-year management plan for an expanding deer herd. Explain this goal to the class, pointing out the effects of overpopulation on habitat and species. Overpopulation leads to damage of habitat as herds of deer overbrowse an area. More deer means less food for each individual. This can result in malnutrition, starvation, disease, and infestation by parasites. Overpopulation also causes increased deer/vehicle collisions and higher crop damage to nearby farmlands. To prevent these and other problems, people must manage deer herds to control their populations.

2. Having established the need for management, briefly discuss methods of population control. Hand out the Data Sheets and tell the class they are managers in charge of a wildlife refuge with an expanding deer herd. Their goal is to control deer numbers over a one-year period, working within a limited budget. They may use one method or combine methods to achieve their goal.



3. Discuss the following management methods with the class, making sure they understand the costs, benefits, and effects of each. (**Note:** All costs are rough estimates, but are stated as precise figures to make the game easier.)

a. Expand Habitat. A plot of land near the refuge is for sale. It will cost $50,000 and will support 50 more deer. This is a way to increase the carrying capacity of the refuge by 50 deer, but what will happen when the herd expands in subsequent years?

b. Improve Habitat. The quality of refuge habitat can be improved by planting shrubs which provide good food and cover for wildlife. For $50,000, 100 deer can be accommodated. For $80,000, 120 deer can be accommodated. For $90,000, 130 deer can be accommodated. This method has the advantage of improving conditions for a wide variety of animals besides deer, but the carrying capacity of the refuge can only be improved to a certain point. Once this optimum carrying capacity is reached, spending more money will have little positive effect.

c. Live Trapping and Relocating Deer. The refuge manager can trap and move deer to another area. However, it costs $600 per deer to catch and move them and few places are available where the deer can be relocated.

d. Professional Removal. Done by hiring an expert to shoot or trap the surplus deer. The professional would charge $150 for each deer removed.

e. Supplemental Feeding. Corn can be bought to support the deer population. The necessary feed will cost $300 per deer. What will happen if the manager had to stop feeding in the winter? When there are more deer born in the spring, what will happen the following winter? Is supplemental feeding a permanent solution to the problem?

f. Sterilization and Introduction of Predators. So far, no practical methods have been found to sterilize large numbers of deer. Also, as was demonstrated in Activity 2, predators such as wolves and mountain lions don't really control deer populations. Predator populations tend to follow the ups and downs of the deer herd, not cause them. Besides, what would be people's reaction when the wolves start to kill pets and livestock of nearby farms and communities? (**Note:** This option is not included on student Data Sheets, but should be brought out in class discussion.)

g. Recreational Hunting. Hunters can be allowed to remove the surplus deer populations. It will cost the refuge $20,000 each year to run the hunter education program and to do patrols and law enforcement work during the hunting season to make sure the laws and hunt rules are observed. At $20,000 the cost to remove 200 deer would be $100/deer. (**Note:** The hunters will actually return a major share of the $20,000 through the purchase of hunting licenses and tags. However, this money would not be paid directly to the refuge in most cases and is not considered as part of this game.)

4. Have each student devise a management plan for their deer herd, using information on the Data Sheet. Give the class 30 minutes to develop their plans.

5. When the students have completed their plans, divide the class into groups of four or five to discuss and pick the most effective plan in the group.Tell them they can combine plans to come up with one best plan. Give the class about a half an hour to do so.

6. Have each group write up and present its plan to the class. Follow up the Activity by discussing the number of combinations, strategies, and options available in wildlife management. Stress that there is no one right answer and that some solutions and options might not work depending on the area, time limits, species to be managed, and resources available to the managers. For instance, expansion of habitat may be limited by surrounding development. Live trapping and removal is usually not a practical solution when managing large animals.

Followup

Have students find newspaper articles and talk to a wildlife manager about actual instances of deer management in their particular area. Have them compare these cases to their own hypothetical management plans. Have students note the budget and other factors influencing decisions and list these.

Activity Review Answers

1. The following are some ways to reduce deer populations: allow hunting; live trap and remove deer to other areas; hire biologists to professionally remove deer (by hunting, etc.).

2. Overpopulation can lead to starvation, disease, infestation by parasites, weakening of individuals, etc., because there is less food, water, and cover available for animals.

3. a, c, d.

4. There may not be enough land available to offset the population growth. More space does not solve the cause of overpopulation; it only treats the symptom. Also, undeveloped land is growing increasingly scarce, and one responsibility of wildlife management is to manage wildlife within the restrictions of money, time, and land available.

Hunting and Wildlife Management

Activity 3

Activity Review

Name:

1. Name three possible ways of reducing the size of an overpopulated deer herd.

a. ____________________

____

b. ____________________

____

c. ____________________

____

2. Why should wildlife populations be managed if there are too many of one species in a given area? List three reasons.

a. ____________________

____

b. ____________________

____

c. ____________________

____

3. If you were a wildlife manager deciding on a plan to solve an overpopulation problem, what would be three factors you would consider in making your plan? Check the three most important factors below.

_____ a. Amount of money in your budget.

_____ b. Number of hunters in your area.

_____ c. Length of time you have to reduce your population.

_____ d. Costs of individual techniques.

_____ e. Amount of land paid for by license fees.

4. List two reasons why buying more land may not solve an over-population problem.

a. ____________________

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b. ____________________

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